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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6: <b>B01F 17/00, B09C 1/02, C11D 3/43, E21B 21/06, C09K 7/06</b>		A1	(11) International Publication Number: <b>WO 95/17244</b> (43) International Publication Date: <b>29 June 1995 (29.06.95)</b>
(21) International Application Number: <b>PCT/US94/08729</b> (22) International Filing Date: <b>2 August 1994 (02.08.94)</b>		(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LT, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD).	
(30) Priority Data: 08/172,429 22 December 1993 (22.12.93) US 08/210,144 17 March 1994 (17.03.94) US		Published <i>With international search report.</i> <i>With amended claims.</i>	
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(54) Title: SOLVENT SOAPS AND METHODS EMPLOYING SAME			
(57) Abstract <p>Compositions comprising (a) a surfactant and (b) a diluent oil are employed in oil-based drilling fluids and processes for cleaning oil-contaminated substrates (e.g., oil-contaminated animals, drill cuttings) as well as in processes for cementing well casings, enhanced oil recovery, and lifting oil from wellbores.</p>			

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## SOLVENT SOAPS AND METHODS EMPLOYING SAME

### BACKGROUND

The present invention relates to non-aqueous-based cleaning fluids, methods for cleaning oil-coated substrates, 5 methods for cleaning oil-contaminated drill cuttings, methods for cementing a well casing in a borehole, enhanced oil recovery procedures, methods for lifting oil from a wellbore, and methods for recovering oil from tar sands.

Non-aqueous-based cleaning fluids are used to 10 clean unwanted oil from substrates, e.g., to remove grease spots from clothing or other fabrics. However, these cleaning fluids tend to dilute and spread the oil, as opposed fully removing it from the substrate. Furthermore, many of these non-aqueous-based cleaning fluids are toxic. 15 Accordingly, there is a need for a non-aqueous-based cleaning fluid, and especially a non-toxic fluid, that more fully removes unwanted oil from substrates.

In addition, there is a need for an oil-contaminated drill cuttings cleaning method that is 20 commercially viable and sufficiently efficacious for cleaned drill cuttings to pass a sheen test. Current methods which may clean drill cuttings sufficiently to pass the sheen test in a laboratory environment (e.g., methods using solvents like pentane or carbon tetrachloride) are impractical for 25 commercial use because the solvents can be toxic, very volatile, and explosive. Such limitations require the use of prohibitively expensive equipment to safeguard against the potential hazards arising from the use of such solvents.

Regarding conventional commercial techniques for 30 cleaning drill cuttings, these methods generally either employ a base oil wash (wherein oil-contaminated drill cuttings are contacted with a base oil in an attempt to remove most of the oil contaminant from the drill cuttings) or a detergent wash (wherein oil-contaminated drill cuttings 35 are washed with an aqueous surfactant solution). The base oil and detergent wash processes are typically capable of reducing the oil content on the cleaned drill cuttings to

only about 5 to about 20 percent, a level not low enough to pass the sheen test.

Another method for cleaning drill cuttings (hereinafter referred to as UNOCLEAN I) was recently 5 disclosed in U.S. Patent 5,156,686, U.S. Patent 5,213,625, U.S. Patent 5,215,596, and U.S. Patent 5,234,577, each of these patents being incorporated herein in their entireties by reference. While the UNOCLEAN I process can clean drill cuttings sufficiently to pass the sheen test, the UNOCLEAN 10 I process has two drawbacks. First, the apparatus employed in the conventional commercial base oil and detergent wash processes must be modified in order to adapt them for use in the UNOCLEAN I process. Second, although the carboxylic acid used in the UNOCLEAN I process is non-toxic, the 15 carboxylic acid must be recycled due to its high cost. The recycling step requires the use of an acid (e.g., HCl) and a base (e.g., NaOH).

There is also a need for a method for cementing casings in wellbores drilled, at least in part, with an oil-based drilling fluid. The current cementing methods tend 20 to leave oil on the wellbore and/or casing surfaces, frequently necessitating the need for expensive, remedial cement squeeze procedures.

Likewise, a demand exists for improved enhanced 25 oil recovery techniques as well as better methods for lifting viscous oils from oil wells.

Furthermore, while commercial technologies exist for extracting oil from water-wet tar sands, there is no commercial technology for removing oil from oil-wet tar 30 sands.

#### SUMMARY OF THE INVENTION

According to one aspect of the invention, there is provided a composition comprising: (a) at least one hydrophilic surfactant having a HLB value of at least about 35 8; and (b) at least one diluent oil.

According to another aspect of the invention, there is provided an oil-based drilling fluid comprising: (a) a base oil; (b) a surfactant; and (c) at least one

ingredient selected from the group consisting of fluid loss control agents, viscosifiers, weighting agents, water, shale stabilizing salts, and lime, characterized in that at least a portion of the surfactant comprises a hydrophilic 5 surfactant having a HLB value of at least about 8. Various methods are also provided.

The invention may provide (a) non-aqueous-based cleaning fluids, including non-toxic fluids, that remove the overwhelming bulk of unwanted oil from substrates, (b) 10 commercially viable techniques for cleaning drill cuttings which remove a sufficient amount of oil from the cuttings for the cleaned drill cuttings to pass the sheen test, (c) well cementing procedures which reduce the need for remedial cement squeezes, (d) an enhanced oil recovery procedure for 15 increasing the recovery of crude oil from subterranean formations, (e) a method for lifting heavy, viscous oils from wellbores, (f) a method for recovering oil from tar sands, and (g) numerous other techniques for removing oil from substrates.

20 The cleaning fluids in one aspect of the present invention comprise a diluent oil and at least one hydrophilic surfactant and can be classified into five major categories. In one version, the cleaning fluid comprises (a) a polar diluent oil having a dipole moment of at least 25 about 0.5 debye (D); and (b) a surfactant selected from the group consisting of polyoxyethylene sorbitan fatty acid esters, isethionates, polyoxyethylene glycol esters, phosphate esters, ethoxylated amides, N-cocoaminobutyric acid, polyethylene glycol esters, tertiary amine oxides, 30 ethoxylated alkyl phenols, alkanolamides, glycerol esters, monoglycerides, monoglyceride derivatives, sulfates of ethoxylated alcohols, sulfates of ethoxylated alkyl phenols, sulfonates of ethoxylated alkyl phenols, sulfonates of alkylaryls, dimethyl alkyl tertiary amines, tridecyl benzene 35 sulfonic acids, dodecyl benzene sulfonic acids, ethoxylated amines, sulfo derivatives of succinates, quaternary surfactants, tertiary amine oxides, and mixtures thereof.

In another version of the invention, the non-aqueous-based cleaning fluid comprises (a) a non-toxic diluent oil and (b) a surfactant.

The non-aqueous-based cleaning fluid of a further 5 version of the invention may be a solution comprising (a) a diluent oil; and (b) a surfactant selected from the group consisting of dimethyl alkyl tertiary amines, tridecyl benzene sulfonic acids, dodecyl benzene sulfonic acids, ethoxylated amines, sulfo derivatives of succinates, 10 quaternary surfactants, tertiary amine oxides, and mixtures thereof.

In a fourth embodiment of the invention, the non-aqueous based cleaning fluid comprises (a) a lipophilic surfactant, (b) a hydrophilic surfactant, and (c) a diluent 15 oil.

The non-aqueous based cleaning fluid of the fifth version of the invention comprises (a) a hydrophilic surfactant having an HLB value of at least about 8 and (b) a diluent oil. In this latter and most preferred version, 20 the diluent oil preferably comprises a polar diluent oil or a combination of polar and nonpolar diluent oils.

Preferably, the foregoing cleaning fluids readily remove oil from oil-covered substrates (e.g., oil-contaminated drill cuttings, oil-contaminated animals, tar 25 sands, grease-coated cooking and eating utensils, and oil-soiled materials such as pavement, fabrics, etc). A general cleaning methodology involves contacting at least a portion of the oil-covered part of the substrate with one of the above-described cleaning fluids. The cleaning fluid 30 dissolves in the oil and, because the surfactant is dissolved in cleaning fluid, the surfactant is distributed throughout the oil. Without being bound by any theory of operation, it is believed that the surfactants employed in the present invention have a sufficient affinity for water 35 so that, when the cleaning fluid-coated, oil-covered article is rinsed with an aqueous fluid, the surfactant emulsifies the contaminant or coating oil and the diluent oil, creating a water external emulsion. The water external emulsion is

readily driven off the substrate by the aqueous fluid rinse, and, frequently, the surface of the substrate is changed from being oil-wet to being water-wet.

Hence, the mode of action of the cleaning fluids 5 of the present invention is quite different from prior cleaning fluids such as (a) aqueous surfactant solutions which act by successively stripping off the outer layer of oil and (b) hydrocarbon solvents which dilute the oil and distribute the diluted oil over a wider area without any 10 mechanism for removing the bulk of the oil from the substrate. In addition, cleaning compositions of the present invention dissolve oil more readily than hydrocarbon solvents (e.g., kerosene).

The cleaning fluids of the invention can also be 15 incorporated into an oil-based drilling fluid. The drilling fluid of this embodiment of the invention comprises (a) a base oil and (b) a surfactant (e.g., an emulsifier and an oil-wetting agent), and (c) at least one drilling fluid additive (e.g., a viscosifier, a weighting agent, and a 20 fluid loss control agent), wherein at least a portion of the surfactant is a hydrophilic surfactant having an HLB value of at least about 8.

Furthermore, the cleaning fluids can be employed in two methods for cementing a well casing in a borehole. 25 In one version, the cleaning fluid is employed as a separate slug and in the other version the cleaning fluid is part of a drilling fluid (such as the one described in the preceding paragraph). The former cementing embodiment comprises the sequential steps of (a) drilling a borehole with a drilling 30 mud into at least a portion of a subterranean formation; (b) placing a well casing in the borehole; (c) displacing the drilling mud from the borehole using a slug of a cleaning fluid of the present invention; (d) passing a slug of an aqueous fluid through the borehole after step (c); and (e) 35 introducing cement into the borehole.

When the cleaning fluid is part of a drilling fluid, the cementing method comprises the sequential steps

of (a) drilling a borehole into a subterranean formation with the cleaning fluid-containing drilling fluid; (b) placing a well casing in the borehole; (c) displacing the drilling mud from the borehole using a slug of an aqueous 5 fluid; and (d) introducing cement into the borehole.

The cleaning fluid can also be employed in oil lifting and an enhanced oil recovery processes. The oil lifting process comprises the steps of (a) contacting crude petroleum in a wellbore with a composition comprising (i) 10 a surfactant and (ii) a diluent oil to form an intermediate composition, and (b) contacting the intermediate composition with water. The enhanced oil-recovery process comprises the sequential steps of (a) injecting a slug of one of the above-described non-aqueous-based cleaning fluids into at 15 least a portion of an oil-bearing subterranean formation; and (b) injecting a slug of an aqueous fluid into at least a portion of the formation contacted by the non-aqueous-based cleaning fluid employed in step (a).

#### DRAWINGS

20 The drill cuttings cleaning, well casing cementing, and oil lifting methodologies as well as other features, aspects, and advantages of the present invention will be better understood with reference to the following description, appended claims, and figures wherein:

25 Figure 1 is a schematic diagram of a drill cuttings cleaning process embodying features of the present invention;

Figure 2 is a schematic cross-sectional view of a wellbore being subjected to the well casing cementing 30 process of the present invention; and

Figure 3 is a schematic cross-sectional view of a wellbore adapted for use in an oil lifting process embodying features of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In the cleaning fluids or compositions of the present invention, one or more hydrophilic surfactants are combined with one or more diluent oils in a manner such that, when the cleaning fluid is applied to oil on a substrate, the hydrophilic surfactants in the cleaning composition are substantially uniformly distributed throughout the oil by the diluent oil. Accordingly, the preferred cleaning compositions of the present invention are believed to be true solutions, i.e., uniformly dispersed mixtures, at a molecular level, of one or more surfactants in one or more diluent oils. In other words, in the preferred cleaning fluids, one or more surfactants are completely dissolved in one or more diluent oils. These preferred cleaning fluids tend to be transparent.

The surfactants employed in the cleaning compositions of the present invention include, but are not limited to, those listed in the following Table I.

TABLE ISurfactants

<u>Class</u>	<u>Exemplary Species</u>
Polyoxyethylene sorbitan fatty acid esters 5	Polyoxyethylene (20) sorbitan monolaurate, polyoxyethylene (20) sorbitan monooleate, polyoxyethylene (20) sorbitan monopalmitate, polyoxyethylene (20) sorbitan trioleate
Isethionates	Coconut acid ester of sodium isoethionate
Polyoxyethylene glycol esters 10	Polyoxyethylene (10) glycol ester
Phosphate esters	Free acid of complex organic phosphate ester
Ethoxylated amines	Polyoxyethylene (5) cocoamine, polyoxyethylene (5) tallowamine, N, N'-tris(2-hydroxymethyl)-n, tallow-1 diaminopropane, polyoxyethylene (10) oleylamine
Ethoxylated amides 15	Polyoxyethylene (5) oleamide

TABLE I (continued)

<u>Class</u>	<u>Surfactants</u>	<u>Exemplary Species</u>
Cocoaminobutyric acids		N-cocoaminobutyric acid
5 Polyethylene glycol esters		Polyethylene glycol oleic acids having 5 moles of ethylene oxide per mole of acid
Tertiary amine oxides		Bis(2-hydroxyethyl)cocoamine oxide, bis(2-hydroxyethyl)taffow amine oxide,
Ethoxylated alkyl phenols		Alkylphenoxypoly(ethyleneoxy) ethanol
10 Alkanolamides		Fatty acid alkanolamide
Glycerol esters		Glycerol monostearate
Monoglycerides and derivatives		Monoglycerides, diglycerides
Sulfates of ethoxylated alcohols		Ammonium salt of ethoxylated sulfate

TABLE I (continued)

<u>Class</u>	<u>Surfactants</u>	
	<u>Exemplary Species</u>	
Sulfates and sulfonates of 5 ethoxylated alkyl phenols	Ammonium salt of sulfated nonylphenoxypoly(ethyleneoxy) ethanol	
Sulfonates of alkylaryls	Sodium alkylaryl sulfonate	
	Dimethyl hydrogenated tallow amine distilled, dimethyl soyamine	
	Tridecyl benzene sulfonic acids	
	Dodecylbenzene sulfonic acids	
10	Sulfo derivatives of succinates	Diocetyl ester of sodium sulfosuccinic acid
	Quaternary surfactants	Dicoco dimethyl ammonium chloride

Because it is always desirable to use a non-toxic substance when practicable and since the surfactants, as detailed more below, tend to end up in rinse water, the surfactant is preferably non-toxic. Exemplary non-toxic 5 surfactants include, but are not limited to, polyoxyethylene sorbitan fatty acid esters, polyoxyethylene glycol esters, polyethylene glycol esters, and glycerol esters.

One or more of the above surfactants are dispersed or, preferably, dissolved in a diluent oil to form the 10 cleaning compositions of the present invention. The diluent oil acts as a solvent, cutting oil on the surface of a substrate and distributing the surfactant throughout the oil.

Typical diluent oils include, but are not limited 15 to, polyalphaolefins (e.g., dimer of 1-decene), white mineral oils, paraffinic solvents, esters, ethers, polybutylenes, polyisobutylenes, silicone oils, crude oils, kerosenes, diesel oils, gasolines, naphthas, aryl halides, heterocyclic compounds, alkyl halides, carboxylic acids, 20 amines, alcohols, aldehydes, ketones, plant oils (e.g., linseed oil, canola oil, soybean oil, corn oil, peanut oil, rapeseed oil, sunflower oil, palm oil, and olive oil), animal oils (e.g., animal fats), terpenes, and terpenoids.

The diluent oil is preferably non-toxic since, as 25 noted above, it is always desirable to use a non-toxic substance whenever possible. Common non-toxic diluent oils include, but are not limited to, polyalphaolefins, white mineral oils, paraffinic solvents, organic esters, ethers, polybutylenes, polyisobutylenes, and silicone oils. In 30 addition, because they are less flammable, the diluent oils preferably have an initial boiling point (as determined in accordance with ASTM D 2887) greater than about 204.4°C (400°F), more preferably at least about 218.3°C, (425°F), even more preferably at least about 232.2°C (450°F), and 35 most preferably at least about 246.1°C (475°F). (Since a numerical range includes all integers and mixed numbers within the limits specified by the range, the recitation of a range in the specification and claims herein specifically

includes a recitation of each integer and mixed number encompassed by the range.)

Due to their low cost and commercial availability, white mineral oils and diesel oils are the preferred diluent 5 oils. Since white mineral oils are non-toxic, they are the most preferred diluent oils.

Some of the surfactants (e.g., polyoxyethylene sorbitan fatty acid esters, dimethyl alkyl tertiary amines, dodecylbenzene sulfonic acid, tridecyl benzene sulfonic 10 acid, ethoxylated amines, sulfo derivatives of succinates, quaternary surfactants, and tertiary amine oxides) are soluble in nonpolar diluent oils. (As used in the specification and claims, the term "nonpolar diluent oil" means a diluent oil having a dipole moment of less than 0.5 15 D.) Exemplary nonpolar diluent oils include, but are not limited to, polyalphaolefins, white mineral oils, paraffinic solvents, polybutylenes, polyisobutylenes, crude oils, kerosenes, diesel oils, gasolines, naphthas, and alkanes having 5 to about 15 carbon atoms (i.e., pentane, hexane, 20 heptane, octane, nonane, decane, undecane, dodecane, tridecane, tetradecane, and pentadecane). The dipole moments of some nonpolar diluent oils are listed below in Table II.

<u>Nonpolar Diluent Oil</u>	<u>Dipole Moment, D</u>
Gasoline	0.17
Mineral Oil	0.22-0.41

Surfactants insoluble in nonpolar diluent oils are dissolved in polar diluent oils or a mixture of polar and nonpolar diluent oils. (As used in the specification and claims, the term "polar diluent oil" means a diluent oil having a dipole moment of at least 0.5 D.) Preferably, the polar diluent oils have dipole moments of at least about 1, more preferably at least about 1.5, even more preferably at least about 2, and most preferably at least about 2.5, 10 D. Exemplary polar diluent oils include, but are not limited to, the oils set forth below in Table III:

TABLE III  
Representative Polar Diluent Oils

<u>Class</u>	<u>Species</u>	
Plant oils	linseed oil, canola oil, soybean oil, corn oil, peanut oil, rapeseed oil, sunflower oil, palm oil, olive oil	
5		
Animal Oils	Animal fats	
Terpenes And Terpenoids	citrus oil, lemon oil, orange oil, rosin oil, pine tar pitch, pine oil, terpineol, limonene	
Aryl Halides	halotoluene <sup>1</sup> , dihalotoluene, dihalobenzene, dihaloalkylbenzene <sup>2</sup>	
10		
Heterocyclic Compounds	furfural, quinoline	
Alkyl Halides	octyl halide <sup>1</sup> , cyclohexyl halide	
Ketones	2,5-hexanedione, 2,6,8-trimethyl isobutylheptylketone, butyrophenone, methyl heptyl ketone, cyclohexanone	

TABLE III (continued)  
Representative Polar Diluent Oils

<u>Class</u>	<u>Species</u>
Carboxylic Acids	valeric acid, caproic acid, heptanoic acid, octanoic acid, nonanoic acid, oleic acid, linoleic acid, linolenic acid, 2-methyl propionic acid, 3-methyl butanoic acid
Amines	aniline, methyl aniline, dimethyl aniline, toluidine, anisidine, haloaniline <sup>1</sup> , tripropylamine, triamyl amine, heptyl amine, dicyclohexyl amine, dibutylamine, tributyl amine, monobutyl diamylamine, octylamine, dioctylamine
Esters	2-ethoxyethyl acetate, ethylene glycol diacetate, 2-butoxyethyl acetate, 2- ethylhexyl acetate, 2-(2-ethoxyethoxy)ethyl acetate, 2-(2-butoxyethoxy)ethyl acetate, glyceryl triacetate, 2,2,4-trimethyl pentanediol, diisobutyrate, glyceryl tributyrate, tributyl phosphate, dimethyl phthalate, diethyl phthalate, dipropyl phthalate, dibutyl phthalate, benzyl acetate, bis(2-ethylhexyl) adipate, undecanoic $\gamma$ -lactone

TABLE III (continued)  
Representative Polar Diluent Oils

<u>Class</u>	<u>Species</u>
Alcohols	hexanol, heptanol, octanol, nonanol, decanol, ethylhexanol, octanol, isooctyl alcohol, cyclohexanol, isodecanol, benzyl alcohol, phenylethanol, 3,5-dimethyl-1-hexanol, 2,2,4-trimethyl-1-pentanol, 2,6-dimethyl-4-heptanol, 3,3,5-trimethylhexanol, diacetone alcohol, furfuryl alcohol, 2-heptyl alcohol
Aldehydes	heptaldehyde, octanal, benzaldehyde, tolualdehyde, phenylacetaldehyde, salicylaldehyde, anisaldehyde, tetrahydrobenzaldehyde
Ethers	phenetole, hexyl ether, dibenzyl ether, butylphenyl ether, amyl phenyl ether, amyl benzyl ether, amyl toyl ether, octyl phenyl ether, hexyl phenyl ether

1. Exemplary halides are bromine, chloride, and iodine.  
 2. The alkyl group generally contains 1 to about 6 carbon atoms, with about 2 carbon atoms being preferred.

Because they are non-toxic, commercially available, and inexpensive, the polar diluent oil is preferably selected from the group consisting of plant oils, animal oils, terpenes, terpenoids, and mixtures thereof.

- 5 The following Table IV sets forth dipole moments of some non-toxic, polar diluent oils.

TABLE IVPolar Diluent Oil Dipole Moments

	<u>Nonpolar Diluent Oil</u>	<u>Dipole Moment, D</u>
10	Terpenes and Terpenoids	
	d-limonene	1.56
	d-pinene	2.67
	Sesquiterpene	0.97-1.12
	Cerin	1.39
15	Vegetable Oils	
	Castor	3.7
	Coconut	2.2
	Linseed	3.0
	Olive	3.03
20	Peanut	2.3
	Poppy	3.06
	Rapeseed	2.7
	Sesame	2.91
	Tung	2.29

25 Due to its commercial availability and pleasant smell, the preferred polar diluent oil is d-limonene.

In a further embodiment of the present invention, the cleaning fluid comprises (a) a lipophilic surfactant, (b) a hydrophilic surfactant, and (c) a diluent oil (which 30 can be a polar diluent oil, a nonpolar diluent oil, or a mixture of polar and nonpolar diluent oils). (As used in the specification and claims, the term "lipophilic

surfactant" means a surfactant having an HLB value of less than 8, and the term "hydrophilic surfactant" means a surfactant having an HLB value of at least 8.) Exemplary lipophilic surfactants include, but are not limited to, 5 sorbitan fatty acid esters (e.g., sorbitan monolaurate, sorbitan monooleate, sorbitan monopalmitate, and sorbitan trioleate) and glycol esters. Some specific lipophilic surfactants are listed (together with their respective HLB values) in the following Table V.

10

TABLE V

<u>Lipophilic Surfactant</u>		<u>HLB Value</u>
<u>Trade Name</u>	<u>Generic Name</u>	
Emsorb 2507	Sorbitan tristearate	2.7
Emsorb 2515	Sorbitan monolaurate	7.4
15 Emerest 2381	Propylene glycol monostearate	4
Emsorb 2500	Sorbitan monooleate	4.8
Span 85	Sorbitan trioleate	1.8
	Glycerol monostearate	3.8
Atmul 651K	Kosher mono & diglycerides	3.5
20 Alkanol DW	Sodium alkylaryl sulfonate	6.7

Typical hydrophilic surfactants include, but are not limited to, polyoxyethylene sorbitan fatty acid esters (e.g., polyoxyethylene (20) sorbitan monolaurate, polyoxyethylene (20) sorbitan monooleate, polyoxyethylene 25 (20) sorbitan monopalmitate, and polyoxyethylene (20) sorbitan trioleate) and polyoxyethylene glycol esters (e.g., polyoxyethylene (10) glycol ester). Some exemplary hydrophilic surfactant species are listed with their respective HLB values in the following Table VI.

TABLE VI

<u>Hydrophilic Surfactant</u>		<u>HLB Value</u>
	<u>Trade Name</u>	<u>Generic Name</u>
5	Emsorb 6907	POE <sup>a</sup> (20) sorbitan tristearate
	Emsorb 6915	POE (20) sorbitan monolaurate
	Emsorb 6900	POE (20) sorbitan monooleate
	Ethofat O-15	Polyethylene glycol oleic acids 5 moles EO <sup>b</sup> per mole acid
10	Emersal 6430	Ammonium lauryl sulfate
	Tween 40	POE (20) sorbitan monopalmitate
	Tween 21	POE (4) sorbitan monolaurate
	<u>Tween 85</u>	<u>POE (20) sorbitan trioleate</u>

a. POE denotes "polyethylene oxide".

b. EO denotes "ethylene oxide".

15           Because hydrophilic surfactant-containing cleaning compositions tend to exhibit the greatest cleaning action, all other parameters being equal, in the most preferred cleaning compositions of the present invention, at least one hydrophilic surfactant is employed. The hydrophilic 20 surfactants preferably have as high a HLB value as possible while maintaining the cleaning composition in a solution state. For nonpolar diluent-containing cleaning compositions, hydrophilic surfactants insoluble in the nonpolar diluent oil are generally solubilized therein by 25 incorporating into the cleaning composition (a) one or more other surfactants soluble in the nonpolar diluent oil, (b) a polar diluent oil, and/or (c) one or more other surfactants soluble in a combination of the nonpolar and polar diluent oils. Since the efficacy of the cleaning 30 composition improves as the HLB value of the hydrophilic surfactant increases (all other factors being held constant), it is preferred that the HLB value of the surfactants employed in above items (a) and (c) be as high as possible and that the difference between the HLB value 35 of the hydrophilic surfactant and the surfactants of items

(a) and (c) be as large as feasible. Accordingly, the difference between the HLB values of the hydrophilic surfactant and the surfactants of items (a) and (b) is generally at least about 0.5, preferably at least about 1, 5 more preferably at least about 1.5, even more preferably at least about 2, and even more preferably at least about 2.5. In fact, it is very desirable for this difference in HLB values to be at least about 3, 3.5, 4, 4.5, and even about 5 or more.

10       The surfactant concentration employed in the cleaning composition of the present invention depends on the intended use of the composition. With this caveat in mind, the surfactant concentration in the cleaning fluid composition typically ranges from about 0.5 to about 50 volume percent (the volume percent being based on the total volume of surfactant(s), polar diluent oil(s), and nonpolar diluent oil(s) in the composition). Often, at least about 1, more often at least about 5, even more often at least about 8, and most often at least about 10, volume percent 15 surfactant is present in the cleaning composition. Frequently, the composition comprises less than about 45, more frequently less than about 40, even more frequently less than about 35, and most frequently less than about 30, volume percent surfactant. Cleaning compositions containing 20 a plurality of hydrophilic surfactants typically have a total hydrophilic surfactant concentration of about 5 to about 20, and more typically about 7 to about 15, volume percent. 25

When a cleaning composition is formed by first 30 combining a surfactant and a polar diluent oil to form an intermediate composition and then combining the intermediate composition with a nonpolar diluent oil to form the cleaning composition, the intermediate composition generally comprises less than about 90, preferably less than about 80, 35 more preferably less than about 70, even more preferably less than about 60, and most preferably less than about 50, volume percent polar diluent oil (the volume percent being based on the total volume of the surfactant and polar

diluent oil in the intermediate composition). Typically, the intermediate composition comprises at least about 5, more typically at least about 10, even more typically at least about 20, and most typically at least about 30, volume 5 percent polar diluent oil. The ratio of the weight of the polar diluent oil to the weight of the surfactant present in the intermediate composition is commonly about 0.1:1 to about 10:1, preferably about 0.2:1 to about 8:1, more preferably about 0.3:1 to about 6:1, even more preferably about 0.4:1 to about 4:1, and most preferably about 0.5:1 to about 2:1.

In the embodiment of the invention employing a combination of lipophilic and hydrophilic surfactants, the ratio of the volume of hydrophilic surfactant to the volume 15 of lipophilic surfactant used in formulating the non-aqueous-based cleaning fluid is generally about 10:1 to about 0.1:1, preferably about 7:1 to about 0.3:1, more preferably about 5:1 to about 0.5:1, even more preferably about 3:1 to about 0.7:1, and most preferably about 2:1 to 20 about 1:1.

In general, as long as the cleaning composition remains homogenous (i.e., in a solution state), the efficacy of the composition increases with (a) increasing hydrophilic surfactant concentration and (b) increasing HLB value of the 25 hydrophilic surfactant employed. Accordingly, the hydrophilic surfactant generally constitutes about 10 to about 100 percent of the total weight of all the surfactants present in the cleaning composition. Preferably, the hydrophilic surfactant comprises at least about 25, more 30 preferably at least about 50, even more preferably at least about 75, and most preferably at least about 90, percent of the total weight of all the surfactants present in the cleaning composition.

With respect to the HLB value of the hydrophilic 35 surfactant, the HLB value is typically at least about 9, preferably at least about 10, more preferably at least about 12, even more preferably at least about 13, and most preferably at least about 14.

Because many of the surfactants employed in forming the compositions of the present invention are believed to have an affinity for water, the intermediate and cleaning compositions preferably contain little, if any, 5 water in order to prevent the surfactant from becoming tied up with water in the compositions. Accordingly, the compositions commonly contain less than about 20, more commonly less than about 10, even more commonly less than about 5, and most commonly less than about 1, volume percent 10 water (the volume percent being based on the total amount of surfactant, diluent oil, and water present in the composition). In fact, the compositions preferably contain less than 0.5, more preferably less than about 0.1, even more preferably less than about 0.05, and most preferably 15 less than about 0.01, volume percent water.

The cleaning compositions of the present invention optionally comprise solids (e.g., diatomaceous earth, bentonite, sand) to act, for example, as scrubbing agents and/or weighting agents. The solids are typically present 20 in a concentration up to about 20 weight percent (the weight percent being based on the total weight of all ingredients present in the composition). When used, the solids are preferably present in a concentration of at least about 0.1, more preferably at least about 0.5, even more preferably at 25 least about 1, and most preferably about 5 to about 15, weight percent.

While liquids and solids other than surfactants and diluent oils are optionally existent in the cleaning compositions of the present invention, the compositions 30 generally contain less than about 10, preferably less than about 5, more preferably less than about 1, even more preferably less than about 0.5, and most preferably less than about 0.01, volume percent liquids other than surfactants and diluent oils (the volume percent being based upon the total volume of the composition). In addition, the compositions typically contain less than about 10, preferably less than about 5, more preferably less than about 1, even more preferably less than about 0.5, and most 35

preferably less than about 0.01, weight percent solids other than any solid surfactants and diluent oils (the weight percent being based upon the total weight of the composition).

5       The cleaning compositions of the present invention are employed, inter alia, to clean oil-covered, -coated, or -contaminated surfaces. In order to reduce the amount of cleaning composition required, these surfaces should preferably be as devoid of water as practicable. For  
10 example, when possible, it is very desirable to shake, wipe, or otherwise remove surface water.

In addition, the viscosity of the cleaning composition can also be adjusted to ensure that the cleaning composition remains in contact with the surface being  
15 cleaned. In particular, a cleaning composition intended for use on a thin (e.g., barbecue grill) or substantially vertical (e.g., wall) surface preferably has a high viscosity so that the cleaning composition tends to remain on the surface where applied, whereas a cleaning composition  
20 employed to clean horizontal, broad surfaces (kitchen counter or stove top) or porous particles (e.g., tar sands) preferably has a low viscosity.

One technique for varying the viscosity of cleaning fluid entails selecting an appropriate diluent oil.  
25      In general, the lower the viscosity of the diluent oil, the greater the solvency action of the cleaning fluid (all other factors being equal). Also, the higher the viscosity of the diluent oil the more the cleaning composition tends to cling to a surface (all other parameter being held constant).  
30      When a low viscosity cleaning composition is desired, a diluent oil (e.g., a mineral oil) having a viscosity typically up to about 0.01 N-sec/m<sup>2</sup> (10 centipoise), and more commonly about 0.004 to about 0.005 N-sec/m<sup>2</sup> (4 to 5 centipoise), is used to formulate the cleaning composition.  
35      However, when a high viscosity cleaning composition is needed, a diluent oil having a viscosity generally greater than about 0.05 N-sec/m<sup>2</sup> (50 centipoise), and more usually

about 0.05 to about 0.1 N-sec/m<sup>2</sup> (50 to 100 centipoise), is employed in preparing the cleaning composition.

In general, an oil-covered article (e.g., oil-covered animals, automotive parts, road surfaces, patios, driveways, rocks, paint brushes, and fabrics (such as clothing, carpeting, linens), as well as smoke-covered articles (such as fireperson's clothing, helmets, tools) and greasy cooking and eating utensils (such as pots, pans, ovens, stoves, grills, dishes)) is contacted with the cleaning composition. Typically, the volumetric ratio of the volume of cleaning composition employed per unit volume of oil adhering to a substrate to be cleaned is at least about 2:1, more typically at least about 5:1, and most typically at least about 10:1. However, another interesting aspect of the present invention is that only a small amount of cleaning composition is actually required to remove an oil adhering to a substrate. In particular, commonly less than 2 (and more commonly about 1.5 or less) unit volumes of cleaning composition are sufficient to remove one unit volume of oil from a substrate.

The cleaning fluid-coated, oil-covered article is preferably stirred or otherwise mixed or manipulated to ensure that all the oil-covered surfaces are contacted with the cleaning composition. As a result of the cleaning composition contacting the oil, the cleaning composition dissolves in the oil, and, because the surfactant is dissolved in or otherwise substantially uniformly dispersed throughout the cleaning composition, the surfactant becomes distributed throughout the oil.

The length of time that the cleaning composition is allowed to remain in contact with the oil-covered article depends on a number of factors, including the specific cleaning composition used, the object to be cleaned, and the type of oil to be removed. Typically, the contact time runs from a fraction of a second to several hours. In general, the contact time is about 1 second to about 24 hours, more commonly about 5 seconds to about 1 hour, even more commonly

about 10 seconds to about 30 minutes, and most commonly about 15 seconds to about 1 minute.

After the end of the desired contact time, the cleaning composition-coated article is rinsed with an aqueous fluid (e.g., water). In order to emulsify and dislodge any oil present in the pores of an oil-coated substrate, the velocity of the water applied to the cleaning composition-coated article is preferably increased with increasing substrate porosity (i.e., increasing surface area per unit weight of the substrate). Accordingly, a porous substrate (e.g., cement) is preferably rinsed using a strong spray or jet of the aqueous fluid.

As noted above, when the cleaning fluid-coated, oil-covered article is rinsed with an aqueous fluid, the surfactant emulsifies the contaminant and diluent oils, creating a water external emulsion. The water external emulsion is readily driven off the substrate by the aqueous fluid rinse and, frequently, the surface of the substrate is changed from being oil-wet to water-wet. (Hence, the manner in which the cleaning compositions of the present invention remove oil from a substrate drastically differs from prior cleaners such as (a) aqueous surfactant solutions which successively remove only a thin, external portion of a layer of oil and (b) hydrocarbon solvents which merely dissolve the oil and spread it over a wider area.)

Generally an excess of aqueous fluid is used to rinse the cleaning fluid-coated, oil-covered article. However, when it is desirable to keep the amount of aqueous fluid employed in the rinsing process down and when the substrate has a low surface area per unit volume (e.g., stainless steel, linoleum), the cleaning fluid-coated oil-covered article can be simply rinsed with a damp cloth.

In a more specific cleaning embodiment, the cleaning fluid is employed to clean drill cuttings. As shown in Figure 1, in a drill cutting cleaning system 10 embodying features of the present invention, oil-contaminated drill cuttings are transported from a shaker screen 12 to a receiving hopper 14 by a chute or other

conduit 16. The drill cuttings are removed at a constant rate from the receiving hopper 14 by a conveyor belt 18 and transported to a rotating drum 20. In the rotating drum 20, the drill cuttings are combined with a cleaning composition 5 introduced through a conduit 22. Preferably, the rotation of the drum 20 causes the drill cuttings and cleaning composition to be constantly mixed or stirred during their transit through the drum 20. The residence time of the drill cuttings in the rotating drum 20 is typically about 10 0.25 to about 15, more typically about 0.5 to about 10, even more typically about 1 about 5, and most typically about 2 to about 3, minutes.

Upon leaving the rotating drum 20, the cleaning composition-coated drill cuttings drop onto a washer shaker 15 screen 24. As the drill cuttings are being transported over the washer shaker screen 24, they are rinsed with water sprayed from a conduit 26. The water removes the bulk of the contaminant oil, diluent oil, and surfactant from the drill cuttings, with these fluids being transported through 20 a conduit 28 to a gravity or centrifugal separator 30. The cleaned drill cuttings are capable of passing the sheen test and can be disposed of using an environmentally acceptable procedure, e.g., by discharge into the ocean (not shown).

The contaminant and diluent oils removed from the 25 drill cuttings rise towards the top of the separator 30 and form an oil phase 32. The oil phase 32 subsequently exits the separator 30 through a conduit 34 and is generally either returned to the drilling mud pit (not shown) or taken to a facility (not shown) for proper disposal or upgrading.

30 As the contaminant and diluent oils rise towards the top of the separator 30, the surfactant and rinse water form an aqueous phase 36 below the oil phase 32. The aqueous phase 36 leaves the separator 30 through a conduit 38. When non-toxic surfactants are employed in the cleaning 35 composition, the aqueous effluent is environmentally safe and dischargeable into the environment without any need for remedial treatment.

The cleaning fluid of the present invention can also be employed in a method for cementing casings in wellbores drilled with an oil-based drilling fluid. With reference to Figure 2, this figure schematically shows a 5 cross-section of a well 100 wherein a well casing 102 is being cemented in a borehole 104 using a well cementing technique embodying features of the present invention. More specifically, in one version of the well casing cementing method of the present invention, after drilling the borehole 10 104 with an oil-based drilling mud 106 into a subterranean formation 108 and placing the well casing 102 in the borehole 104, the drilling mud 106 is displaced from the borehole 104 using a slug 110 of the cleaning composition of the present invention. Next, a slug 112 of an aqueous 15 fluid, e.g., water, is passed through the borehole 104 to remove the cleaning composition slug 110 and any residual drilling mud 106 from the surface 114 of the borehole 104 and the inside surface 116 and the outside surface 118 of the well casing 102. Finally, a sufficient amount of a slug 20 120 of cement is introduced into the borehole 104 to cement the well casing 102 in the borehole 104.

The sizes of the cleaning composition slug 110 and rinse water slug 112 employed in the well cementing process of the present invention are dependent upon, inter alia, the 25 annulus volume between the outside surface 118 of the well casing 102 and the borehole surface or wall 114, the interior volume defined by the inside surface 116 of the well casing, the volume of drilling mud in the borehole 104, the type of drilling mud being displaced, and the type of 30 cement being used. Usually, the volume of the cleaning composition slug 110 runs from about 0.02 to about 1, more commonly about 0.04 to about 0.75, even more commonly about 0.05 to about 0.5, and most commonly about 0.075 to about 0.3, times the sum of the annulus and interior volumes. 35 Typically, the size of aqueous fluid rinse slug 112 employed is at least about 0.5, more typically at least about 1, even more typically at least about 2, and most typically at least

about 3, times the volume of the cleaning composition slug 110.

A significant aspect of the present version of the well cementing technique of the present invention is that, 5 while a spacer fluid is optionally employed between the aqueous fluid rinse slug 112 and the cement slug 120 in the well casing cementing process of the present invention, no spacer is needed. Therefore, a spacer is preferably not employed in the cementing process of the present invention.

10 The cleaning fluid of the present invention can also be used in enhance oil recovery and oil lift operations. In an enhanced oil recovery technique embodying features of the present invention, one or more slugs of a cleaning composition within the scope of the present 15 invention is injected into at least a portion of an oil-bearing subterranean formation. Next, an aqueous drive fluid (e.g., water, steam) is injected into at least a portion of the subterranean formation contacted by the cleaning fluid. A sufficient amount of the aqueous drive 20 fluid is preferably employed so that at least a portion of the injected aqueous fluid is produced from one or more producing wells. Alternatively, after the initial injection of the aqueous drive fluid, another drive fluid (e.g., carbon dioxide or other inert gas) is optionally injected 25 in place of the aqueous drive fluid.

In the oil lift process of the present invention, the cleaning fluid is employed to aid in lifting heavy oils from a wellbore. As shown in Figure 3, an oil production system 200 comprises a wellbore 202 penetrating into a 30 subterranean formation 204. The wellbore 202 is fitted with a tubing 206 for transporting the cleaning composition to a heavy oil (not shown) located proximate the bottom 208 of the wellbore 202. The cleaning composition commingles with the heavy oil as the oil rises in the wellbore 202. In 35 addition, an aqueous fluid (e.g., water) is transported down the wellbore 202 through another tubing 210. The water exiting the second tubing 210 mixes with the heavy oil/cleaning composition mixture and forms a fluid having

a viscosity less than that of the heavy oil. The resulting fluid, which is more readily produced from the wellbore 202, is transported to a separating tank (not shown) where the oil is separated from the water. The separated oil is sent 5 to a refinery (not shown) and the separated water is either reused in the foregoing process or disposed of in an environmentally acceptable manner.

The cleaning compositions of the present invention are also employed in an oil-based drilling fluid. The oil-based drilling fluid embodying features of the present invention comprises (a) a base oil, (b) a surfactant (e.g., emulsifiers and oil-wetting agents), and (c) at least one ingredient selected from the group consisting of fluid loss control agents, viscosifiers, weighting agents, water, shale 15 stabilizing salts, and lime. The drilling fluid is distinguished in that at least a portion of the surfactant is a hydrophilic surfactant. As described in more detail below, the presence of the hydrophilic surfactant in the drilling fluid enables the implementation of drill cuttings 20 cleaning and cementing processes even less complicated than the respective streamlined methods discussed above.

As noted in the preceding paragraph, the drilling fluid of the invention is characterized in that the surfactant comprises a hydrophilic surfactant. In general, 25 as the concentration of the hydrophilic surfactant in the drilling fluid increases, the amount of residual oil present on the drill cuttings decreases after being subjected to the simplified drill cuttings cleaning procedure described below. Accordingly, the drilling fluid typically comprises 30 about 0.5 to about 15, preferably about 1 to about 10, more preferably about 2 to about 9, even more preferably about 3 to about 8, and most preferably about 4 to about 7, weight percent hydrophilic surfactant (i.e., the weight of the hydrophilic surfactant divided by the weight of all 35 ingredients employed to formulate the drilling fluid, the quotient being multiplied by 100 percent).

In relationship to any other surfactants employed in the drilling fluid, the hydrophilic surfactant typically

comprises at least about 10, preferably at least about 25, more preferably at least about 50, even more preferably at least about 60, and most preferably at least about 70, weight percent of the total surfactant content of the  
5 drilling fluid (i.e., the weight of the hydrophilic surfactant divided by the weight of all surfactants employed to formulate the drilling fluid, the quotient being multiplied by 100 percent). In fact, the hydrophilic surfactant can comprise at least about 75, 80, 85, 90, 95  
10 or more weight percent of the total surfactant content of the drilling fluid. Accordingly, the hydrophilic surfactant can comprise even 100 weight percent of the total surfactant content of the drilling fluid.

In addition, as the HLB value of the hydrophilic surfactant in the drilling fluid increases, the amount of residual oil present on the drill cuttings also decreases after being subjected to the simplified drill cuttings cleaning procedure described below, provided that the hydrophilic surfactant is well dispersed throughout, and  
20 preferably dissolved in, the base oil component of the drilling fluid. Hence, the hydrophilic surfactant preferably has a HLB value greater than 8, such as at least about 9, 10, 11, 12, 13, 14, and 15 or more.

Various techniques are employed to ensure that the  
25 hydrophilic surfactant is uniformly distributed or dissolved in the base oil used in the drilling fluid. One method entails employing a plurality of surfactants. Since like substances tend to dissolve like substances, the presence in the drilling fluid of one surfactant (e.g., a lipophilic  
30 or hydrophilic surfactant) that is soluble in the base oil facilitates the dissolution of another surfactant having a higher HLB value and which otherwise would not be soluble in the base oil. Preferably, at least two hydrophilic surfactants are present in the drilling fluid.

35 Another technique for ensuring that the hydrophilic surfactant is uniformly distributed or dissolved in the drilling fluid entails the use of one or more of the polar diluent oils described above. Since the use of a

polar diluent oil adds to the cost of the resulting drilling fluid, it is preferred to use as little polar diluent oil as possible. When employed, the ratio of the weight of polar diluent oil to the weight of hydrophilic surfactant 5 present in the drilling fluid is commonly about 0.1:1 to about 5:1, preferably about 0.2:1 to about 4:1, more preferably about 0.3:1 to about 3:1, even more preferably about 0.4:1 to about 2:1, and most preferably about 0.5:1 to about 1.5:1. Quite often, the ratio of the weight of 10 polar diluent oil to the weight of hydrophilic surfactant present in the drilling fluid is about 1:1.

To enable the aqueous effluent produced from the drill cuttings cleaning processes described below to be dischargeable into the environment without any need for 15 remedial treatment, the hydrophilic surfactant is preferably non-toxic. The polyoxyethylene sorbitan fatty acid esters and polyethylene glycol esters listed above in Table VI are exemplary non-toxic, hydrophilic surfactants.

Any base oil used in oil-based drilling fluid, 20 e.g., diesel oil, mineral oils, crude oil, and polyalphaolefins, are suitable for use in the present invention. In addition, the white mineral oil described in copending U.S. patent application Serial No. 08/065,644, filed May 21, 1993 (and which is incorporated herein in its 25 entirety by reference) can be used as the base oil. One advantage arising from the use of polyalphaolefins, white mineral oils, or other non-toxic oils as the base oil (especially in combination with non-toxic surfactants) is that the drilling operator has the option of either 30 discarding or washing oil-covered drill cuttings produced during the drilling operation. Another advantage of using such non-toxic oils is that some, if not all, of any oil left on washed drill cuttings will be non-toxic.

One or more emulsifiers, wetting agents, 35 viscosifiers, weighting agents, fluid loss control agents, and shale inhibiting salts are also optionally used in the oil-based drilling fluid of the present invention.

Exemplary species of these optional materials are listed in the following Table VII.

TABLE VII

Optional Oil-Based Drilling Fluid Additives

5	<u>Genus</u>	<u>Species</u>
	Emulsifiers	Fatty acids, soaps of fatty acids, and fatty acid derivatives including amido-amines, polyamides, polyamines, esters (such as sorbitan monoleate polyethoxylate, sorbitan dioleate polyethoxylate), imidazolines, and alcohols
10		
	Wetting agents	Lecithin, fatty acids, crude tall oil, oxidized crude tall oil, organic phosphate esters, modified imidazolines, modified amidoamines, alkyl aromatic sulfates, alkyl aromatic sulfonates, and organic esters of polyhydric alcohols
15		
	Viscosifiers	Organophilic clays (e.g., hectorite, bentonite, and attapulgite), oil soluble polymers, polyamide resins, polycarboxylic acids and soaps, and sulfonated elastomers
20		
	Weighting agents	Barite, iron oxide, gelana, siderite, and calcium carbonate
25	Non-polymeric fluid loss control agents	Asphaltics (e.g., asphaltenes and sulfonated asphaltenes), amine treated lignite, and gilsonite
	Shale inhibiting salts	Alkali metal and alkaline-earth metal salts (calcium chloride and sodium chloride being preferred)

TABLE VII (continued)Optional Oil-Based Drilling Fluid Additives

<u>Genus</u>	<u>Species</u>
Polymeric 5 fluid loss control agents	Polystyrene, polybutadiene, polyethylene, polypropylene, polybutylene, polyisoprene, natural rubber, butyl rubber, polymers consisting of at least two monomers selected from the group consisting of styrene, butadiene, isoprene, and vinyl carboxylic acid
10	

For drilling fluids intended for use in high temperature environments (e.g., where the bottom hole temperature exceeds about 204.4°C (400°F)), it is desirable to employ a sulfonated elastomer polymeric viscosifier and 15 a polymeric fluid loss control agent in order to obtain improved rheological properties at this elevated temperature. Preferably, the sulfonated elastomer polymeric viscosifier is a neutralized sulfonated elastomer polymer having about 5 to about 100 milliequivalents of sulfonate 20 groups per 100 g of sulfonated polymer. More preferably, the neutralized sulfonated elastomer polymer has about 5 to about 50 milliequivalents, and most preferably about 5 to about 30 milliequivalents, of sulfonate groups per 100 g of sulfonated polymer.

25 Preferably, the sulfonated elastomer polymeric viscosifier is derived from an elastomer polymer selected from the group consisting of ethylene-propylene-diene monomer (EPDM) terpolymers, copolymers of isoprene and styrene sulfonate salt, copolymers of chloroprene and 30 styrene sulfonate salt, copolymers of isoprene and butadiene, copolymers of styrene and styrene sulfonate salt, copolymers of butadiene and styrene sulfonate salt, copolymers of butadiene and styrene, terpolymers of isoprene, styrene, and styrene sulfonate salt, terpolymers

of butadiene, styrene, and styrene sulfonate salt, butyl rubber, partially hydrogenated polyisoprenes, partially hydrogenated polybutylene, partially hydrogenated natural rubber, partially hydrogenated buna rubber, partially 5 hydrogenated polybutadienes, and Neoprene. Methods for obtaining and characteristics of sulfonated elastomer polymers are known to those skilled in the art. See, for example, U.S. Patent 4,447,338, U.S. Patent 4,425,462, U.S. Patent 4,153,588, U.S. Patent 4,007,149, U.S. Patent 10 3,912,683, and UK Patent Application 2,212,192, these documents being incorporated in their entirety by reference.

The preferred polymeric fluid loss control agents are styrene-butadiene copolymers. Characteristics of exemplary styrene-butadiene copolymers are listed in the 15 following Table VIII:

TABLE VIII

<u>Characteristic</u>	<u>Exemplary Styrene-Butadiene Copolymers</u>			
Styrene/-				
Butadiene Ratio	50/50	57/43	90/10	67/33
20 Surfactant Type	Anionic	Anionic	Anionic	Anionic
Tg, °C	-22	-11	76	12
pH	9.0	6.0	6.5	9.0

All the styrene/butadiene copolymers described in above Table VIII also contain about 1 to about 3 weight 25 percent copolymerized carboxylic acid (e.g., itaconic acid and acrylic acid).

A typical oil-based drilling fluid of this version of the present invention contains the ingredients and properties set forth in the following Table IX:

TABLE IX

<u>Ingredient</u>	<u>Typical</u>	<u>Preferred</u>
Base oil, volume % <sup>a</sup>	25-85	50-60
Surfactant (active), ppb <sup>b,c</sup>	1-20	1-10
5 Water, volume % <sup>a</sup>	up to 45	10-20
Weighting agent, ppb	up to 600	150-400
Organophilic clay, ppb	0.5-30	1-10
Fluid loss control agent, ppb	up to 30	2-15
Viscosifier, ppb	0.02-2	0.05-1.5
10 Shale inhibiting salt, ppb	up to 60	20-30
Lime, ppb <sup>d</sup>	up to 30	1-10
<u>Property</u>		
Density, ppg <sup>e</sup>	7.5-20	9-16
a. Volume percent is based on the total volume of the drilling fluid.		
15 b. The pounds per barrel (ppb) is based upon the final composition of the drilling fluid.		
c. The pounds per barrel (ppb) is based upon the final composition of the drilling fluid.		
20 d. As used in the specification and claims, the term "lime" means quicklime (CaO), quicklime precursors, and hydrated quicklime (e.g., slaked lime (Ca(OH) <sub>2</sub> )).		
e. ppg denotes pounds per gallon.		

An exemplary oil-based drilling fluid of the present invention for use in high temperature formations contains the ingredients and properties set forth below in Table X.

TABLE X

<u>Ingredient</u>	<u>Typical</u>	<u>Preferred</u>
Oil, volume %*	25-85	50-60
Surfactant (active), 5 pounds per barrel (ppb) <sup>b,f</sup>	1-20	1-10
Water, volume %*	up to 45	10-20
Weighting agent, ppb	up to 600	150-400
Organophilic clay, ppb	0.5-30	1-10
Non-polymeric fluid loss control 10 agent, ppb	up to 30	2-15
Polymeric fluid loss control agent, ppb <sup>c</sup>	3-12	5-10
Sulfonated elastomer polymeric viscosifier, ppb <sup>d</sup>	0.02-2	0.05-1.5
15 Shale inhibiting salt, ppb	up to 60	20-30
Lime, ppb	up to 30	1-10
<u>Property</u>		
<u>Density, ppg</u>	<u>7.5-20</u>	<u>9-16</u>

- a. Volume percent is based on the total volume of the  
20 drilling fluid.
- b. As used in the specification and claims, the term  
"surfactant" means a substance that, when present at  
low concentration in a system, has the property of  
25 adsorbing onto the surfaces or interfaces of the  
system and of altering to a marked degree the surface  
or interfacial free energies of those surfaces (or  
interfaces). As used in the foregoing definition of  
surfactant, the term "interface" indicates a boundary  
between any two immiscible phases and the term  
30 "surface" denotes an interface where one phase is a  
gas, usually air. Exemplary ingredients referred to  
as surfactants by those skilled in the art include  
emulsifiers and oil wetting agents.
- c. The polymeric fluid loss control agent is preferably  
35 present in the drilling fluid in a concentration of  
about 6 to about 9 ppb.

- d. The sulfonated elastomer polymeric viscosifier is preferably present in the drilling fluid in a concentration of about 0.1 to about 1 ppb.
  - e. ppg denotes pounds per gallon.
- 5 f. The pounds per barrel (ppb) is based upon the final composition of the drilling fluid.

The volumetric ratio of oil to water in the drilling fluids of the present invention can be as low as about 50:50.

10 Preferably, the weight ratio of the polymeric fluid loss control agent to the sulfonated elastomer polymeric viscosifier is about 1.5:1 to about 50:1, more preferably about 3:1 to about 20:1, and most preferably about 5:1 to about 10:1.

15 The drilling fluids are preferably prepared by mixing the constituent ingredients in the following order: (a) base oil, (b) organophilic clay, (c) surfactant, (d) lime, (e) an aqueous solution comprising water and the shale inhibiting salt, (f) non-polymeric fluid loss control agent, 20 (g) weighting agent, (h) polymeric fluid loss control agent (when used), and (i) viscosifier.

The hydrophilic surfactant-containing drilling fluids enable the implementation of the following simplified drill cuttings cleaning and well casing cementing 25 techniques. With reference to Figure 1, in the simplified drill cutting cleaning process of the present invention, the drill cutting cleaning system 10 is modified such that oil-contaminated drill cuttings are transported by a conduit 16 from a first shaker screen 12 to a washer or second shaker screen 24. Accordingly, the modified drill cutting cleaning 30 process makes use of the receiving hopper 14, the conveyor belt 18, the rotating drum 20, the addition of an external cleaning composition, and the conduit 22 optional, and, in fact, unnecessary. The remaining portion of the simplified 35 drill cuttings process is the same as the drill cutting cleaning process described previously.

Hence, the hydrophilic surfactant-containing drilling fluid enables the use of a drill cutting cleaning process which requires virtually no additional chemical cost (the hydrophilic surfactant used in the drilling fluid can 5 replace some, if not all, of the emulsifiers and wetting agents previously used in oil-based drilling fluids) and little additional equipment cost (since at least one shaker screen is conventionally used in drilling operations to separate the bulk of the drilling fluid from the drill 10 cuttings). In addition, since drill cuttings coated with the hydrophilic surfactant-containing drilling fluids, when washed, can be discharged into the environment, the hydrophilic surfactant-containing drilling fluids of the present invention have the potential to render obsolete 15 expensive alternative drilling fluids as well as costly conventional drill cuttings washing and reinjection procedures.

As noted above, when the hydrophilic surfactant-containing drilling fluid is employed to drill a borehole, 20 a simplified well cementing technique can be used. The simplified well cementing technique employs all the steps and slugs of the cementing procedure described above with one exception, namely, the cleaning composition-containing slug 110 shown in Figure 2 is rendered optional, and, in 25 fact, not necessary.

The size of the rinse water slug 112 employed in this version of the well cementing process of the present invention is also dependent upon the parameters noted in the previously described well cementing process. Usually, the 30 volume of the rinse water slug 112 employed in this embodiment of the well cementing process runs from about 0.01 to about 5, more commonly about 0.1 to about 4, even more commonly about 0.5 to about 3, and most commonly about 1 to about 2, times the sum of the annulus and interior 35 volumes.

EXAMPLES

The following examples (which are intended to illustrate and not limit the invention, the invention being defined by the claims) describe (a) screening procedures used to identify surfactants suitable for use in the present invention (Examples 1-54); (b) the preparation of exemplary four-component cleaning compositions (Examples 55-59); (c) processes for cleaning drill cuttings (Examples 60-61, 63-67), (d) the preparation of an exemplary three-component cleaning composition (Example 62); (e) a set of comparative experiments for recovering oil from tar sands (Examples 68-71); and (f) procedures for removing spots (Examples 72 and 75), cleaning barbecue grills (Example 73), and treating oil-contaminated paper (Example 74).

15

Examples 1-54Nonpolar Diluent Oil Solubility Test

To determine whether a surfactant is soluble in a nonpolar diluent oil, roughly 1 ml surfactant was dissolved in approximately 20 ml white mineral oil.

20 Polar Diluent Oil Solubility Test

If a surfactant was not soluble in the white mineral oil when subjected to the foregoing Nonpolar Diluent Oil Solubility Test, about 2 ml of the surfactant was dissolved in about 2 ml of d-limonene oil and/or about 2 ml 25 of pine oil. If the surfactant was soluble in the polar diluent oil, the surfactant/polar diluent combination was combined with roughly 20 ml nonpolar diluent oil to determine whether the surfactant was soluble in the surfactant/polar diluent/nonpolar diluent-containing 30 composition.

Alternatively, sometimes when the surfactant (roughly 1 ml) did not dissolve in the white mineral oil (approximately 20 ml), about 2 ml of limonene oil or 2 ml of pine oil was added to the surfactant/nonpolar diluent oil 5 combination to determine whether the surfactant was soluble in the surfactant/polar diluent/nonpolar diluent-containing composition.

The surfactants were rated according to the following rating system and the results of the foregoing 10 solubility tests are set forth below in Table A.

Solubility Rating Scale

<u>Rating</u>	<u>Performance</u>
A	Soluble in white mineral oil
B	Soluble in white mineral oil in the presence of 15 limonene and/or pine oil
C	Soluble in limonene and/or pine oil only
D	Insoluble in all oils tested

Cleaning Test

To assess the cleaning efficacy of exemplary 20 cleaning compositions of the present invention, a bottle brush having a brush diameter of about 1 inch and a brush length of about 4 inches was coated at one end with approximately 1-3 ml crude oil. The coated portion of the brush was then immersed, with stirring, for roughly 10 to 25 15 seconds in a cleaning composition that had received a rating of A, B, or C in the above-described Diluent Oil Solubility Tests. The treated brush was then taken out of the cleaning composition and rinsed with a strong spray of water.

30 In some instances, a cleaning composition was simply sprayed with a jet of water to determine the ability of the composition to foam or otherwise demonstrate its cleaning ability. The cleaning tests showed excellent

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correlation in that compositions that performed well in one also performed well in the other.

The detergency performance of the various surfactants tested were rated using the following scale.

5 <u>Detergency Rating Scale</u>	
	<u>Rating</u> <u>Performance</u>
	1               Foamed and turned white (best)
	2               Turned white
	3               Foamed only
10	4               Lackluster performance
	5               Formed calcium precipitate with water
	6               Did nothing

The results of the cleaning tests are also listed below in Table A.

15   Toxicity Rating Scale

The toxicity of the various surfactants employed in these examples were rated based upon publicly available information using the following system.

20 <u>Toxicity Rating Scale</u>	
	a   Non-toxic
	b   Intermediate toxicity
	c   Toxic

The toxicity ratings of the surfactants are also set forth below in Table A.

TABLE A

<u>Ex</u>	<u>Trade Name</u>	<u>Generic Name</u>	<u>Cone.*</u>	<u>Type</u>	<u>Rating<sup>b</sup></u>
1	Emsorb 2507	Sorbitan tristearate	100	Nonionic	5-A-a
5	Emsorb 2515	Sorbitan monolaurate	100	Nonionic	4-A-a
3	Emerest 2381	Propylene glycol monostearate	100	Anionic	5-A-b
4	Emsorb 6907	POE <sup>c</sup> (20) sorbitan tristearate	100	Nonionic	1-B-a
10	Emsorb 6915	POE (20) sorbitan monolaurate	100	Nonionic	3-C-a
6		Propylene carbonate			3-D-c
7	Emsorb 6900	POE (20) sorbitan monooleate	100	Nonionic	3-C-a
15	Igepon AC-78	Coconut acid ester of sodium isoethionate	83	Anionic	3-C-b
9	Armeen DMHTD	Dimethyl hydrogenated tallow amine distilled	100	Cationic	4-A-c
20	Ethofat 0-20	POE (10) glycol oleate	100	Nonionic	3-C-a

TABLE A (continued)

<u>Ex</u>	<u>Trade Name</u>	<u>Generic Name</u>	<u>Class</u>	<u>Conc.<sup>a</sup></u>	<u>Type<sup>c</sup></u>	<u>Rating<sup>b</sup></u>	
11	Antara LP-700	Free acid of complex organic phosphate ester	Phosphate ester	100	Anionic	3-D-b	
5 12	Gafac PE-510	Free acid of complex organic phosphate ester	Phosphate ester	100	Anionic	1-C-b	
13	Gafac Emulphor EL-719	Polyoxyethylated vegetable oil	Ethoxylated fatty esters	96	Nonionic	2-D-a	
14	Petrostep A-60	Dodecylbenzene sulfonic acid				4-A-b	
10	15	Gantrez AN-149	Methyl vinyl ether & maleic anhydride copolymer	Vinyl & other polymeric resin	100	Anionic	5-D-b
16	Ethomeen C/15	POE (5) cocoamine	Ethoxylated amine	100	Cationic	2-A-c	
15 17	Ethomeen T/15	POE (5) tallowamine	Ethoxylated amine	100	Cationic	2-A-c	
18	Ethomid O/15	POE (5) oleamide	Ethoxylated amide		Cationic	1-B-c	
19	Ethoduomeen T/13	N,n' tris(2-hydroxymethyl)-n, tallow-1 diaminopropane	Ethoxylated amine	100	Cationic	4-A-b	
20	Armeen Z	N-cocoaminobutyric acid		100	Amphoteric	3-B-b	

TABLE A (continued)

<u>Ex</u>	<u>Trade Name</u>	<u>Generic Name</u>	<u>Class</u>	<u>Conc.<sup>a</sup></u>	<u>Type</u>	<u>Rating<sup>b</sup></u>	
21	Ethofat O-15	Polyethylene glycol oleic acids 5 moles EO per mole acid	Glycol ester	100	Nonionic	2-B-a	
5	22	Aromox C/12	Bis(2-hydroxyethyl) cocoamine oxide	Tertiary amine oxide	50	Cationic	3-C-c
23	Ethomeen 18/15	POE (5) octadecyl amine	POE ethoxylated amine		Cationic	2-A-c	
10	24	Aluminum stearate	Fatty ester			6-A-b	
25	Emerest 2310	Isopropyl isostearate	Fatty ester			6-A-b	
26	Armeen DMSD	Dimethyl soyamine	Dimethyl alkyl tertiary amine	100	Cationic	4-A-c	
27	Emersal 6440	Alkanolamine lauryl sulfate	Sulfate of alcohol	75	Anionic	3-D-2	
15	28	Emisorb 2500	Sorbitan monooleate	Sorbitan derivative	100	Nonionic	6-A-a
29	Emery 6731	Cocamide DEA lauryl sulfate	Sulfate of alcohol	100	Anionic / Nonionic	3-D-b	
20	30	Ethomeen 0/15	POE (10) oleylamine	Ethoxylated amine	Cationic	2-A-c	

TABLE A (continued)

<u>Ex</u>	<u>Trade Name</u>	<u>Generic Name</u>	<u>Class</u>	<u>Conc.<sup>a</sup></u>	<u>Type</u>	<u>Rating<sup>b</sup></u>
31	Aerosol OT-S	Diocetyl ester of sodium sulfosuccinic acid	Succinates, sulfo derivatives	70	Anionic	3-A-b
5	32	Monoethyl acid orthophosphate	Phosphate derivative			6-D-b
33	Emersal 6430	Ammonium lauryl sulfate	Sulfates of alcohol	28	Anionic	3-D-b
34	Argquad 2C-75	Dicoco dimethyl ammonium chloride	Quaternary surfactant	75	Cationic	1-A-c
10	35	Aromox T/12	Bis(2-hydroxyethyl) tallow amine oxide	50	Cationic	3-A-b
36		Sodium 2-ethylhexyl sulfate	Sulfates & sulfonates of oils			6-D-b
15	37	Igepal CTA-639	Alkylphenoxypoly-(ethyleneoxy) ethanol	Ethoxylated alkyl phenol	Nonionic	1-C-b
38	Span 85	Sorbitan trioleate	Sorbitan derivative	100	Nonionic	6-A-a
39		Polyvinyl pyrrolidone	Heterocyclic			3-D-3
20	40	Triton X-55	Phosphate surfactant, potassium salt	50	Anionic	3-D-b

TABLE A (continued)

<u>Ex</u>	<u>Trade Name</u>	<u>Generic Name</u>	<u>Class</u>	<u>Conc.<sup>a</sup></u>	<u>Type</u>	<u>Rating<sup>b</sup></u>
41	Triton QS-30	Phosphate surfactant in free acid form	Phosphate ester	90	Anionic	3-B-b
5	Ninol 128 extra fatty acid alkanolamide	Alkanolamide			Nonionic	2-C-c
43	Glycerol monostearate	Glycerol ester			1-B-a	
44	Surflo OW-1	Oxyethylated glycerol ester of a fatty acid esters & oils	Ethoxylated fatty esters & oils	58	Nonionic	3-D-a
45	Witcamide 5130	Modified alkanolamide	Alkanolamide	98	Anionic / Nonionic	6-D-c
10	Igepon T-27	Sodium n-methyl-n-oleyl laurate	Lanolin-based derivative	67	Anionic	6-D-a
47	Tween 40	POE (20) sorbitan monopalmitate	POE sorbitan derivative	100	Nonionic	3-C-a
15	Atmuls 651K	Kosher mono & diglycerides	Monoglycerides & derivatives	100	Nonionic	6-B-1
49	Tween 21	POE (4) sorbitan monolaurate	POE sorbitan derivative	100	Nonionic	1-B-a
50	Tween 85	POE (20) sorbitan trioleate	POE sorbitan derivative	100	Nonionic	3-C-a
20						

TABLE A (continued)

<u>Ex</u>	<u>Trade Name</u>	<u>Generic Name</u>	<u>Class</u>	<u>Conc.<sup>a</sup></u>	<u>Type</u>	<u>Rating<sup>b</sup></u>
51	Alipal CD-128	Ammonium salt of ethoxylate sulfate	Sulfates of ethoxylated alcohol	58	Anionic	3-C-b
5	52 Alipal EP-110	Ammonium salt of sulfated nonylphenoxy-poly(ethyleneoxy)ethanol	Sulfates of EO alkyl phenol	30	Anionic	3-C-b
53	Alkanol DW	sodium alkylarylsulfonate	Sulfates of alkylaryl		Anionic	3-C-b
10	54 Span 40	sorbitan monopalmitate	Sorbitan derivative	100	Nonionic	5-A-a

- a. Conc. denotes percent active ingredient in the material tested.
- b. The ratings are in accordance with the detergency, solubility, and toxicity rating scales noted above.
- c. POE denotes "polyoxyethylene".

The results listed in Table A indicate that certain surfactants dissolve in nonpolar and/or polar diluent oils and that certain of the resulting compositions remove contaminant oil from a substrate.

5

Examples 55-59Preparation Of Exemplary Four-Component Cleaning Compositions

In each of Examples 55-59, a cleaning composition was prepared by dissolving Emsorb 6907 brand POE (20) sorbitan tristearate in d-limonene with gentle heating at a temperature of about 37.8°C (100°F) to about 48.9°C (120°F). The resulting mixture was then blended with a nonpolar diluent oil to form a blend. Emsorb 6900 brand POE (20) sorbitan monooleate was then added to the blend to form the cleaning composition. The weight and weight percent of each additive and the specific nonpolar diluent oil used are noted in the following Table B.

TABLE B  
Exemplary Cleaning Compositions

<u>Ingredient</u>	<u>Example</u>			
	<u>55</u>		<u>56</u>	
	<u>q</u>	<u>wt%</u>	<u>q</u>	<u>wt%</u>
POE(20) sts <sup>a</sup>	3.3	9	10	14.7
d-limonene	3	8.2	8.5	12.5
wmo <sup>b</sup>	2.9	79.2	44	64.7
fae <sup>c</sup>	0	0	0	0
10 diesel	0	0	0	0
POE(20) smo <sup>d</sup>	1.3	3.6	5.5	8.1
	<u>q</u>	<u>wt%</u>	<u>q</u>	<u>wt%</u>
			<u>57</u>	<u>58</u>
			<u>q</u>	<u>wt%</u>
POE(20) sts <sup>a</sup>			3.5	9.5
d-limonene			3	8.2
wmo <sup>b</sup>			0	0
fae <sup>c</sup>			29	78.8
10 diesel			0	0
POE(20) smo <sup>d</sup>			1.3	3.5
	<u>q</u>	<u>wt%</u>	<u>q</u>	<u>wt%</u>
			<u>59</u>	<u>59</u>
			<u>q</u>	<u>wt%</u>
POE(20) sts <sup>a</sup>			10	14.6
d-limonene			8.5	12.4
wmo <sup>b</sup>			0	0
fae <sup>c</sup>			44	64.2
10 diesel			0	0
POE(20) smo <sup>d</sup>			6	8.8

a. "POE(20)sts" denotes Emsorb 6907 brand POE (20) sorbitan tristearate.

b. "wmo" denotes Peneteck brand white mineral oil.

c. "fae" denotes Petrofree brand ester.

15 d. "POE(20)smo" denotes Emsorb 6900 brand POE (20) sorbitan monooleate.

The composition of Example 55 remains in a solution state at temperatures down to about 18.3°C (65°F). Techniques for keeping the composition of Example 55 in or close to a solution state at temperatures below about 18.3°C  
 5 (65°F) include (a) replacing some or all of the white mineral oil with a more polar diluent (e.g., Petrofree brand ester or d-limonene), and/or (b) reducing the concentration one or more of the hydrophilic surfactants (e.g., the concentration of Emsorb 6907 brand POE (20) sorbitan  
 10 tristearate).

Examples 60-61

Drill Cuttings Cleaning Process

Old, dehydrated drill cuttings (about 100 g) coated with a drilling fluid that contained LVT-200 brand  
 15 base oil was mixed with gentle stirring (roughly 5 minutes) with various amounts of the cleaning composition prepared in above Example 55. The cleaning composition-coated drill cuttings were then put on an 100 mesh screen and vigorously sprayed with water. The results of these experiments are  
 20 summarized in the following Table C.

TABLE C  
Drill Cutting Cleaning Results

	<u>Example</u>	<u>Cleaning Composition, g</u>	<u>Concentration On</u>		<u>Results</u>
			<u>Cuttings, wt %</u>	<u>200</u>	
25	60	20		200	No Oily Odor
	61	2		20	No Oily Odor

- a. The weight percent is based upon the weight of the cleaning composition divided by the weight of the drilling fluid-coated drill cuttings, the quotient being multiplied by 100%.

Based upon previous observations, cleaned drill cuttings, which have no oily odor, also pass the sheen test and typically contain less than about 1 weight percent residual oil, based on the dry weight of the cleaned 5 cuttings. To confirm that the cleaned drill cuttings could pass the sheen test, the cleaned cuttings were ground using a mortar and pestle, placed in a centrifuge tube containing about 60 g water, and centrifuged (at about 3,000 g force). After being centrifuged, no sheen was observed on the water 10 in the centrifuge tube.

Example 62

Preparation Of Exemplary Three-Component Cleaning Composition

A three component cleaning composition was 15 prepared by dissolving about 3.3 g Emsorb 6907 brand POE (20) sorbitan tristearate in about 3 g d-limonene with gentle heating at a temperature of about 37.8°C (100°F) to about 48.9 °C (120°F). The resulting mixture was then blended with about 1.3 g Emsorb 6900 brand POE (20) sorbitan 20 monooleate to form the cleaning composition.

Examples 63-64Drill Cuttings Cleaning Process

Old, dehydrated drill cuttings (about 10 g) coated with a drilling fluid that contained LVT-200 brand base oil 5 was mixed with gentle stirring (roughly 5 minutes) with various amounts of the cleaning composition prepared in above Example 62. The cleaning composition-coated drill cuttings were then put on an 100 mesh screen and vigorously sprayed with water. The results of these experiments are 10 summarized in the following Table D.

TABLE DDrill Cutting Cleaning Results

<u>Example</u>	<u>Cleaning Composition, g</u>	<u>Concentration On Cuttings, wt %<sup>a</sup></u>	<u>Results</u>
5			Oily Residual Odor Oil, wt% <sup>b</sup>
63	1.6	3.3	Slight 5.6
64	N/M <sup>c</sup>	>100	Slight 3.6
<p>a. The weight percent is based upon the weight of the cleaning composition divided by 5 g (the presumed weight of the drilling fluid on 10 g of coated drill cuttings), the quotient being multiplied by 100%.</p> <p>b. The weight percent residual oil (as determined by a laboratory retort analysis) is based on the dry weight of the cleaned cuttings.</p> <p>c. "N/M" means not measured.</p>			

Example 65Drill Cuttings Cleaning Process

A drilling fluid (about 50 g) having the make-up shown in the following Table E was mixed with about 50g of shale having a particle size of about 5-7 mesh.

TABLE EDrilling Fluid Composition

<u>Ingredient</u>	<u>Quantity</u>
Conoco LVT-200 brand base oil	0.58 bbl
5 Invermul NT brand blend of amine derivatives and tall oil fatty acids	8 lb/bbl
EZmul NT brand blend of amine derivatives	4 lb/bbl
Duratone HT brand amine treated lignite	6 lb/bbl
10 Lime	8 lb/bbl
Geltone II brand amine bentonite	5 lb/bbl
Water	0.13 bbl
CaCl <sub>2</sub>	37.4 lb/bbl
RM63 brand polymer	1 lb/bbl
15 Barite	263 lb/bbl
Rev Dust brand simulated drill solids	10 lb/bbl

Next, the drilling fluid coated shale was mixed with gentle stirring (roughly 5 minutes) with about 1.6 g of the cleaning composition prepared in above Example 62.

20 The resulting mixture was then put on an 100 mesh screen and vigorously sprayed with water. The cleaned shale was devoid of any oily odor and had a residual oil content of about 1.5 weight percent based on the dry weight of the cleaned cuttings.

25

Example 66Drill Cuttings Cleaning Process

The drilling fluid (about 50 g) described in above Table E was mixed with about 50 g of shale having a particle of about 5-7 mesh. Next, the drilling fluid coated shale

30 was mixed with gentle stirring (roughly 5 minutes) with about 7.95 g of the cleaning composition prepared in above Example 55. The resulting mixture was then put on an 100

mesh screen and vigorously sprayed with water. The cleaned shale was devoid of any oily odor and had a residual oil content of about 0.82 weight percent based on the dry weight of the cleaned cuttings.

5

Example 67Drill Cuttings Cleaning Process

The procedure described in Example 66 was repeated with one modification, namely, the shale was ground to reduce the particle size. The cleaned shale obtained using 10 this modified procedure was also devoid of any oily odor, but had a residual oil content of about 1.4 weight percent based on the dry weight of the cleaned cuttings.

Examples 68-71Tar Sands Oil Recovery Processes

15       The following protocol was employed in each of Examples 68-71. Oil-wet tar sand was simulated by coating fine silica sand (about 40-60 mesh) with an extremely viscous, tarry crude oil (about 5-10 API gravity). (The simulated tar sand contained about 10 weight percent crude 20 oil.) The simulated tar sand (about 50 g) was contacted with a composition, using gentle stirring, for about 5 minutes to dissolve the heavy crude in the composition and form a slurry. Next, the slurry was placed on a 100 mesh screen. Water was then sprayed on the slurry. The wash 25 water was allowed to flow into a large beaker, where any oil separation was observed. Finally, the clean sand was analyzed or observed to determine the oil content of the clean sand. The results of these experiments are reported in the following Table F.

TABLE F

<u>Ex</u>	<u>Composition</u>	<u>Amount</u>	<u>Results</u>
67	Cleaning composition of Example 59	5 g	0 wt% residual oil on cleaned sand (by retort analysis). Recovered oil separated slowly from the wash water.
68	Cleaning composition of Example 59 (1 part) diluted with diesel oil (5 parts)	5 g	No residual oil on cleaned sand (by observation). Recovered oil separated rapidly from wash water.
69	Diesel	5 g	Most of the oil remained on the simulated tar sands.
70	Cleaning composition of Example 62	5 g	Substantially all of the oil remained on the simulated tar sands.

The results reported in the above Table F indicate that oil can be very effectively extracted from tar sands using the cleaning composition of Example 59. In addition, chemical costs can be reduced and oil separation enhanced without sacrificing extraction efficiency by using very low concentrations of the cleaning compositions of Example 59. Furthermore, while the cleaning composition of Example 62 has many suitable applications, e.g., use in an oil-based drilling fluid for cleaning drill cuttings, it is not effective for removing oil from tar sands. The reason for the latter result is that the cleaning composition of Example 62 lacks a sufficient amount of a diluent oil (e.g., diesel, mineral oil) having the ability to lower the viscosity of the viscous oil on the simulated tar sands and distribute the hydrophilic surfactants throughout such viscous oil. Accordingly, the composition of Example 62 would be effective for removing oil from tar sands if it

were used in larger amounts and/or if it were reformulated to contain a higher concentration of d-limonene.

Example 72

Spot Remover

5           Crude oil was accidentally splashed onto a sleeve cuff of a shirt and formed an oily spot (about 0.64 cm (0.25 inch) in diameter). The cleaning composition of Example 57 (roughly 1-2 ml) was applied and rubbed into the spotted portion of the cuff. After waiting a few seconds, the  
10          treated area of the cuff was sprayed with water. This procedure completely removed the oily spot from the garment.

Example 73

Barbecue Grill Cleaner

15          The cleaning composition of Example 55 was liberally applied with a dry dish brush to a well used barbecue grill caked with food grease and smoke residue. The cleaning was done on a patio and a scouring pad was used on areas of the grill that were highly carbonized. After being rinsed with a garden hose, the treated grill, the dish  
20          brush, and the patio were virtually spotless.

Example 74

Process For Treating Oil-Contaminated Paper

25          Fine, oil-coated paper particles containing about 5 weight percent lubricant oil were treated with the cleaning composition of Example 55 (about 5 weight percent of the cleaning composition was employed based on the weight of the oil-coated paper treated). The resulting mixture was thoroughly kneaded and then placed on a 100 mesh screen and rinsed with water. The cleaned paper particles exhibited

no oily smell and looked the same as another sample of the oil-coated paper that had been treated with an excessive amount of pentane.

Example 75

5

Spot Remover

Pants soiled with about four motor oil spots (each spot being about 2.54 cm (1 inch)) were washed using a commercial detergent in a washing machine. The spots were still on the washed pants. About 5-10 ml of the cleaning  
10 composition of Example 55 was then applied and rubbed into each spot. After waiting a few seconds, the treated areas of the pants were sprayed with water. This cleaning composition completely removed the motor oil spots from the pants. The cleaned pants were then washed with the  
15 commercial detergent in the washing machine to remove any residual cleaning composition

While a detergent was used when the cleaned pants were washed in the washing machine, none was actually necessary. In fact, after rubbing the cleaning composition  
20 into the spots, the pants could simply have been rinsed in the washing machine with just water.

Although the present invention has been described in detail with reference to some of the preferred embodiments, other versions are possible. For example, in  
25 addition to using the cleaning compositions of the present invention in the above-described drill cuttings wash, well casing cementing, and oil lifting techniques, other oil- and surfactant-containing compositions can be employed. Exemplary of such other compositions include, but are not limited to, those described in Japanese Patent 5098297,  
30 Japanese Patent 5098292, Japanese Patent 5098283, Japanese Patent 4110400, European Patent 426942, Japanese Patent 2248500, Japanese Patent 2123199, East German Patent 268971, Japanese Patent 1092295, and U.S. Patent 4,707,293, these

documents being incorporated herein in their entireties by reference.

Also, with reference to Figure 1, in addition to or in place of introducing the cleaning composition through conduit 22 to contact the drill cuttings in the rotating drum 20, the cleaning composition can also be introduced through another conduit (not shown) to contact the drill cuttings as they are being transported on the conveyor belt 18. Furthermore, a stirred vessel can be used in place of the rotating drum 20 to mix the cleaning composition and drill cuttings.

Another variation in the drill cuttings cleaning system shown in Figure 1 entails recycling the separated oil leaving the separator 30 through the conduit 34 for reuse as part or all of the oil portion of the cleaning fluid composition injected into the rotating drum 20 through conduit 22. In this embodiment of the invention, make-up surfactant is introduced into the recycled oil to form the cleaning composition injected into rotating drum 20.

Likewise, the water exiting the separator 30 through the conduit 38 in Figure 1 is optionally recycled and used as the rinse water sprayed through the conduit 26 onto the cleaning composition-coated drill cuttings located on the shaker screen 24.

Additionally, in the well cementing process of the present invention, a slug of fluid (e.g., diesel, kerosene) is optionally inserted between the oil-based drilling mud and the slug of the cleaning composition.

Furthermore, the cleaning compositions of the present invention can be used to remove oil-soluble paint (e.g., graffiti made using a spray can that employs an organic carrier vehicle). In addition, the cleaning compositions can efficaciously cleanse the human body, e.g., they can replace facial and bath soaps for removing natural or excessive oil build-up as well as supplant harsh cleansers used for scrubbing hands soiled with oil and/or grease. Also, these cleaning compositions can be employed as a machine lubricant.

60

In view of the numerous additional embodiments noted above, the spirit and scope of the appended claims should not necessarily be limited to the description of the preferred versions contained herein.

CLAIMS

1. A composition comprising:
  - (a) at least one hydrophilic surfactant having a HLB value of at least about 8; and
  - (b) at least one diluent oil.
2. The composition of claim 1 comprising at least one polar diluent oil.
3. The composition of any preceding claim comprising at least one nonpolar diluent oil.
4. The composition of any preceding claim wherein the composition is a solution.
5. The composition of any preceding claim wherein at least one hydrophilic surfactant has a HLB value of at least about 10.
6. The composition of any one of claims 1-3 or 4 wherein at least one hydrophilic surfactant has a HLB value of at least about 12.
7. The composition of any one of claims 1-3 or 4 wherein at least one hydrophilic surfactant has a HLB value of at least about 14.
8. The composition of any one of claims 1-3 or 4 wherein at least one hydrophilic surfactant has a HLB value of at least about 15.
9. The composition of any one of claims 1-3 or 4 comprising at least two hydrophilic surfactants having HLB values of at least 8.

10. The composition of any one of claims 1-3 or 4 comprising at least two hydrophilic surfactants having HLB values of at least 8, wherein at least one of the hydrophilic surfactants is not soluble in a comparative material consisting of the insoluble hydrophilic surfactant and the same diluent oil(s) present in the composition, the respective volumes of the insoluble hydrophilic surfactant and the diluent oil(s) in the comparative material being the same as employed in the composition.

11. The composition of any preceding claim wherein at least one hydrophilic surfactant is non-toxic.

12. The composition of any preceding claim wherein at least one diluent oil is non-toxic.

13. The composition of any preceding claim wherein each hydrophilic surfactant is non-toxic.

14. The composition of any preceding claim wherein each diluent oil is non-toxic.

15. The composition of any preceding claim comprising about 0.5 to about 50 weight percent hydrophilic surfactant.

16. The composition of any preceding claim wherein the surfactant is selected from the group consisting of sorbitan derivatives, polyoxyethylene sorbitan derivatives, polyoxyethylene sorbitan glycol esters, polyoxyethylene fatty esters, glycerol esters, ethoxylated oils, lanolin-based derivatives, and mixtures thereof and the diluent oil is selected from the group consisting of polyalphaolefins, white mineral oils, paraffinic solvents, organic esters, ethers, polybutylenes, polyisobutylenes, silicone oils, plant oils, animal oils, terpenes, terpenoids, and mixtures thereof.

17. The composition of any preceding claim wherein the surfactant is selected from the group consisting of sorbitan derivatives, polyoxyethylene sorbitan derivatives, and mixtures thereof and the diluent oil is selected from the group consisting of polyalphaolefins, white mineral oils, plant oils, animal oils, terpenes, terpenoids, and mixtures thereof.

18. A method for cleaning an oil-coated substrate, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-coated part of the substrate with the composition of any preceding claim; and

(B) rinsing at least a portion of the oil-coated substrate contacted in step (A) with water.

19. A method for removing oil from tar sands, the method comprising the sequential steps of:

(A) contacting at least a portion of the tar sands with the composition of any one of claims 1-16 or 17; and

(B) rinsing at least a portion of the tar sands contacted in step (A) with water to form a fluid comprising oil and water.

20. The method of claim 19 wherein the tar sands are oil-wet.

21. An oil-based drilling fluid comprising:

(a) a base oil;

(b) a surfactant; and

(c) at least one ingredient selected from the group consisting of fluid loss control agents, viscosifiers, weighting agents, water, shale stabilizing salts, and lime, characterized in that at least a portion of the surfactant comprises a hydrophilic surfactant having a HLB value of at least about 8.

22. The oil-based drilling fluid of claim 21 wherein at least about 10 weight percent of the surfactant is the hydrophilic surfactant.

23. The oil-based drilling fluid of claim 21 wherein at least about 25 weight percent of the surfactant is the hydrophilic surfactant.

24. The oil-based drilling fluid of claim 21 wherein at least about 50 weight percent of the surfactant is the hydrophilic surfactant.

25. The oil-based drilling fluid of claim 21 wherein at least about 75 weight percent of the surfactant is the hydrophilic surfactant.

26. The oil-based drilling fluid of claim 21 wherein at least about 95 weight percent of the surfactant is the hydrophilic surfactant.

27. The oil-based drilling fluid of any one of claims 21-25 or 26 comprising at least about 0.5 weight percent hydrophilic surfactant.

28. The oil-based drilling fluid of any one of claims 21-25 or 26 comprising at least about 1 weight percent hydrophilic surfactant.

29. The oil-based drilling fluid of any one of claims 21-25 or 26 comprising at least about 2 weight percent hydrophilic surfactant.

30. The oil-based drilling fluid of any one of claims 21-28 or 29 comprising less than about 15 weight percent hydrophilic surfactant.

31. The oil-based drilling fluid of any one of claims 21-28 or 29 comprising less than about 10 weight percent hydrophilic surfactant.

32. The oil-based drilling fluid of any one of claims 21-30 or 31 further comprising a polar diluent oil.

33. The oil-based drilling fluid of any one of claims 21-30 or 31 further comprising a polar diluent oil wherein the ratio of the weight of polar diluent oil to the weight of the hydrophilic surfactant is at least about 0.1:10.

34. The oil-based drilling fluid of any one of claims 21-32 or 33 comprising a plurality of hydrophilic surfactants having HLB values of at least about 8.

35. The oil-based drilling fluid of any one of claims 21-33 or 34 wherein the hydrophilic surfactant is non-toxic.

36. The oil-based drilling fluid of any one of claims 21-34 or 35 wherein the base oil is non-toxic.

37. A method for drilling a borehole in a subterranean formation, the method comprising the steps of:

(A) rotating a drill bit at the bottom of the borehole; and

(B) introducing a drilling fluid into the borehole (i) to pick up drill cuttings and (ii) to carry at least a portion of the drilling cuttings out of the borehole, wherein the drilling fluid is oil-based drilling fluid of any one of claims 21-35 or 36.

38. A method for cleaning oil-coated drill cuttings, the method comprising the step of contacting drill cuttings having at least a portion of their surface coated by the oil-based drilling fluid of any one of claims 21-35

or 36 with water to remove at least a portion of the oil from the drill cuttings and to form a fluid comprising oil removed from the surface of the drill cuttings and water.

39. A method for cementing a well casing in a borehole, the method comprising the sequential steps of:

(A) drilling the borehole with the oil-based drilling fluid of any one of claims 21-35 or 36 into at least a portion of a subterranean formation;

(B) passing a slug of water through the borehole; and

(C) introducing cement into the borehole.

40. A method for removing oil from an oil-spotted fabric, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-spotted part of the fabric with the composition of any one of claims 1-17 or 18; and

(B) rinsing at least a portion of the oil-spotted fabric contacted in step (A) with water.

41. A method for cleaning oil-soiled cooking and eating utensils, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-soiled part of a utensil with the composition of any one of claims 1-17 or 18; and

(B) rinsing at least a portion of the oil-soiled utensil contacted in step (A) with water.

42. A method for cleaning oil-coated paper, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-coated part of the paper with the composition of any one of claims 1-17 or 18; and

(B) rinsing at least a portion of the oil-coated paper contacted in step (A) with water.

43. A method for removing oil from the surface of a human body, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-coated part of the human body with the composition of any one of claims 1-17 or 18; and

(B) rinsing at least a portion of the oil-coated human body contacted in step (A) with water.

44. The composition of any one of claims 1-17 or 18 comprising less than about 20 volume percent water.

45. The composition of any one of claims 1-17 or 18 comprising less than about 10 volume percent water.

46. The composition of any one of claims 1-17 or 18 comprising less than about 5 volume percent water.

47. The composition of any one of claims 1-17 or 18 comprising less than about 1 volume percent water.

48. A method for cleaning an oil-coated substrate, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-coated part of the substrate with the composition of any one of claims 1-17 or 18; and

(B) rinsing at least a portion of the oil-coated substrate contacted in step (A) with water (i) to emulsify the diluent oil and the oil present on the substrate and (ii) to create a water external emulsion.

## AMENDED CLAIMS

[received by the International Bureau on 20 March 1995 (20.03.95);  
original claims 1-48 replaced by amended claims 1-48 (7 pages)]

1. A composition comprising:
  - (a) at least two hydrophilic surfactants having HLB values of at least 8; and
  - (b) at least one diluent oil.
2. The composition of claim 1 comprising at least one polar diluent oil.
3. The composition of any preceding claim comprising at least one nonpolar diluent oil.
4. The composition of any preceding claim where the composition is a solution.
5. The composition of any preceding claim where at least one hydrophilic surfactant has a HLB value of at least about 9.
6. The composition of any preceding claim where at least one hydrophilic surfactant has a HLB value of at least about 10.
7. The composition of any one of claims 1-3 or 4 where at least one hydrophilic surfactant has a HLB value of at least about 12.
8. The composition of any one of claims 1-3 or 4 where at least one hydrophilic surfactant has a HLB value of at least about 13.
9. The composition of any one of claims 1-3 or 4 where at least one hydrophilic surfactant has a HLB value of at least about 14.

10. The composition of any one of claims 1-3 or 4 where at least one hydrophilic surfactant has a HLB value of at least about 15.

11. The composition of any one of claims 1-4 or 6-10 comprising at least two surfactants having HLB values of at least about 10.

12. The composition of any preceding claim where at least one of the hydrophilic surfactants is not soluble in a comparative material consisting of the insoluble hydrophilic surfactant and the same diluent oil(s) present in the composition, the respective volumes of the insoluble hydrophilic surfactant and the diluent oil(s) in the comparative material being the same as employed in the composition.

13. The composition of any preceding claim where at least one hydrophilic surfactant is non-toxic.

14. The composition of any preceding claim where at least one diluent oil is non-toxic.

15. The composition of any preceding claim where each hydrophilic surfactant is non-toxic.

16. The composition of any preceding claim where each diluent oil is non-toxic.

17. The composition of any preceding claim comprising about 0.5 to about 50 volume percent hydrophilic surfactant (the volume percent being based on the total volume of surfactants and diluent oils in the composition).

18. The composition of any one of claims 1-15 or 16 comprising about 1 to about 30 volume percent hydrophilic surfactant (the volume percent being based on the total volume of surfactants and diluent oils in the composition).

19. The composition of any one of claims 1-15 or 16 comprising about 5 to about 20 volume percent hydrophilic surfactant (the volume percent being based on the total volume of surfactants and diluent oils in the composition).

20. The composition of any one of claims 1-15 or 16 comprising about 7 to about 15 volume percent hydrophilic surfactant (the volume percent being based on the total volume of surfactants and diluent oils in the composition).

21. The composition of any preceding claim where the surfactant is selected from the group consisting of sorbitan derivatives, polyoxyethylene sorbitan derivatives, polyoxyethylene sorbitan glycol esters, polyoxyethylene fatty esters, glycerol esters, ethoxylated oils, lanolin-based derivatives, and mixtures thereof and the diluent oil is selected from the group consisting of polyalphaolefins, white mineral oils, paraffinic solvents, organic esters, ethers, polybutylenes, polyisobutylenes, silicone oils, plant oils, animal oils, terpenes, terpenoids, and mixtures thereof.

22. The composition of any preceding claim where the surfactant is selected from the group consisting of sorbitan derivatives, polyoxyethylene sorbitan derivatives, and mixtures thereof and the diluent oil is selected from the group consisting of polyalphaolefins, white mineral oils, plant oils, animal oils, terpenes, terpenoids, and mixtures thereof.

23. The composition of any preceding claim comprising at least two diluent oils, where the surfactant is selected from the group consisting of sorbitan derivatives, polyoxyethylene sorbitan derivatives, and mixtures thereof, one diluent oil is selected from the group consisting of terpenes, terpenoids, and mixtures thereof, and another diluent oil is selected from the group consisting of polyalphaolefins, white mineral oils, plant oils, animal oils, and mixtures thereof.

24. The composition of any preceding claim comprising less than about 1 volume percent water (the volume percent being based on the total amount of surfactants, diluent oils, and water present in the composition).

25. The composition of any one of claims 1-22 or 23 comprising less than about 0.5 volume percent water (the volume percent being based on the total amount of surfactants, diluent oils, and water present in the composition).

26. The composition of any one of claims 1-22 or 23 comprising less than about 0.1 volume percent water (the volume percent being based on the total amount of surfactants, diluent oils, and water present in the composition).

27. The composition of any one of claims 1-22 or 23 comprising less than about 0.05 volume percent water (the volume percent being based on the total amount of surfactants, diluent oils, and water present in the composition).

28. The composition of any one of claims 1-22 or 23 comprising less than about 0.01 volume percent water (the volume percent being based on the total amount of surfactants, diluent oils, and water present in the composition).

29. The composition of any one of claims 1-22 or 23 substantially devoid of water.

30. The composition of any preceding claim comprising less than about 10 volume percent of all liquid ingredients other than surfactants and diluent oils (the volume percent being based on the total volume of the composition).

32. The composition of any one of claims 1-28 or 29 comprising less than about 5 volume percent of all liquid ingredients other than surfactants and diluent oils (the volume percent being based on the total volume of the composition).

33. The composition of any one of claims 1-28 or 29 comprising less than about 1 volume percent of all liquid ingredients other than surfactants and diluent oils (the volume percent being based on the total volume of the composition).

34. The composition of any one of claims 1-28 or 29 comprising less than about 0.05 volume percent of all liquid ingredients other than surfactants and diluent oils (the volume percent being based on the total volume of the composition).

35. The composition of any one of claims 1-28 or 29 comprising less than about 0.01 volume percent of all liquid ingredients other than surfactants and diluent oils (the volume percent being based on the total volume of the composition).

36. The composition of any preceding claim comprising less than about 5 weight percent of all solid ingredients other than surfactants and diluent oils (the weight percent being based on the total weight of the composition).

37. The composition of any one of claims 1-34 or 35 comprising less than about 1 weight percent of all solid ingredients other than surfactants and diluent oils (the weight percent being based on the total weight of the composition).

38. The composition of any one of claims 1-34 or 35 comprising less than about 0.5 weight percent of all solid ingredients other than surfactants and diluent oils (the weight percent being based on the total weight of the composition).

39. A composition comprising:  
(a) at least one hydrophilic surfactant having HLB values of at least 8;  
(b) a first diluent oil selected from the group consisting of terpenes, terpenoids, and mixtures thereof; and  
(c) at least one other diluent oil.

40. A method for cleaning an oil-coated substrate, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-coated part of the substrate with the composition of any preceding claim; and

(B) rinsing at least a portion of the oil-coated substrate contacted in step (A) with water.

41. A method for removing oil from tar sands, the method comprising the sequential steps of:

(A) contacting at least a portion of the tar sands with the composition of any one of claims 1-38 or 39; and

(B) rinsing at least a portion of the tar sands contacted in step (A) with water to form a fluid comprising oil and water.

42. The method of claim 41 wherein the tar sands are oil-wet.

43. A method for cementing a well casing in a borehole, the method comprising the sequential steps of:

(A) drilling the borehole with an oil-based drilling fluid;

(B) passing a slug of the composition of any one of claims 1-38 or 39 through the borehole;

(C) passing a slug of water through the borehole; and

(D) introducing cement into the borehole.

44. A method for removing oil from an oil-spotted fabric, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-spotted part of the fabric with the composition of any one of claims 1-38 or 39; and

(B) rinsing at least a portion of the oil-spotted fabric contacted in step (A) with water.

45. A method for cleaning oil-soiled cooking and eating utensils, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-soiled part of a utensil with the composition of any one of claims 1-38 or 39; and

(B) rinsing at least a portion of the oil-soiled utensil contacted in step (A) with water.

46. A method for cleaning oil-coated paper, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-coated part of the paper with the composition of any one of claims 1-38 or 39; and

(B) rinsing at least a portion of the oil-coated paper contacted in step (A) with water.

47. A method for removing oil from the surface of a human body, the method comprising the sequential steps of:

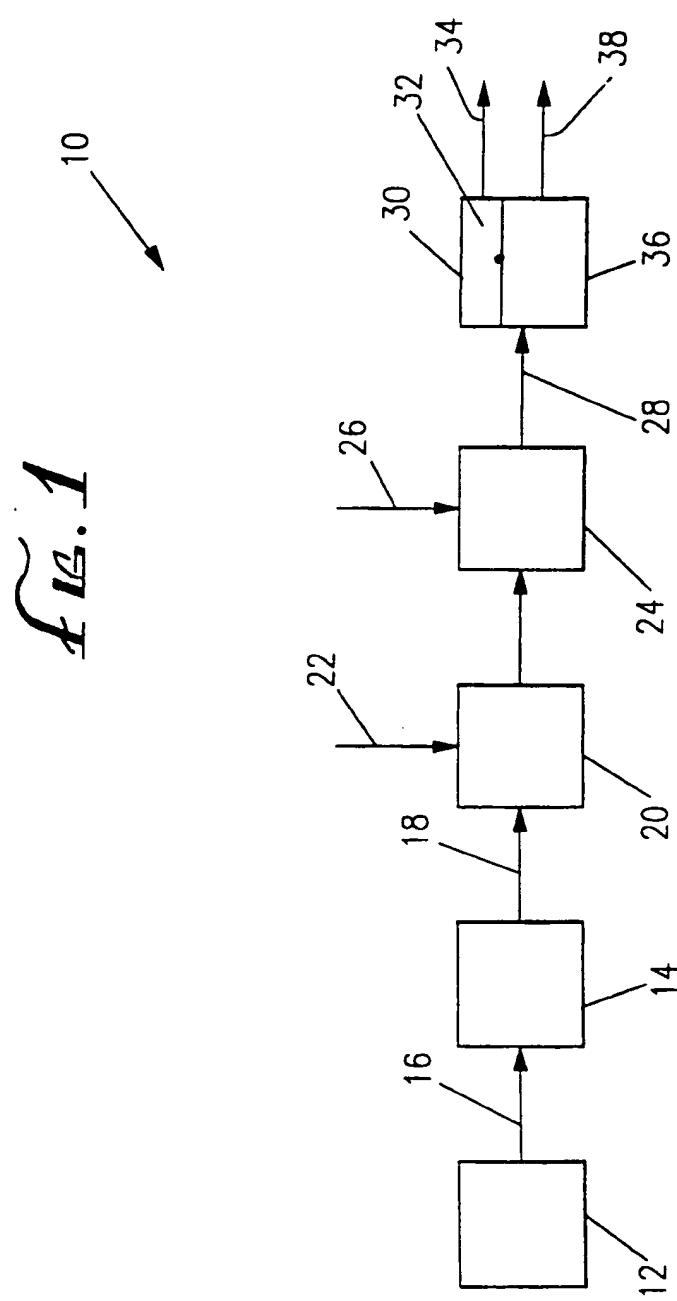
(A) contacting at least a portion of the oil-coated part of the human body with the composition of any one of claims 1-38 or 39; and

(B) rinsing at least a portion of the oil-coated human body contacted in step (A) with water.

48. A method for cleaning an oil-coated substrate, the method comprising the sequential steps of:

(A) contacting at least a portion of the oil-coated part of the substrate with the composition of any one of claims 1-38 or 39; and

(B) rinsing at least a portion of the oil-coated substrate contacted in step (A) with water (i) to emulsify the diluent oil and the oil present on the substrate and (ii) to create a water external emulsion.



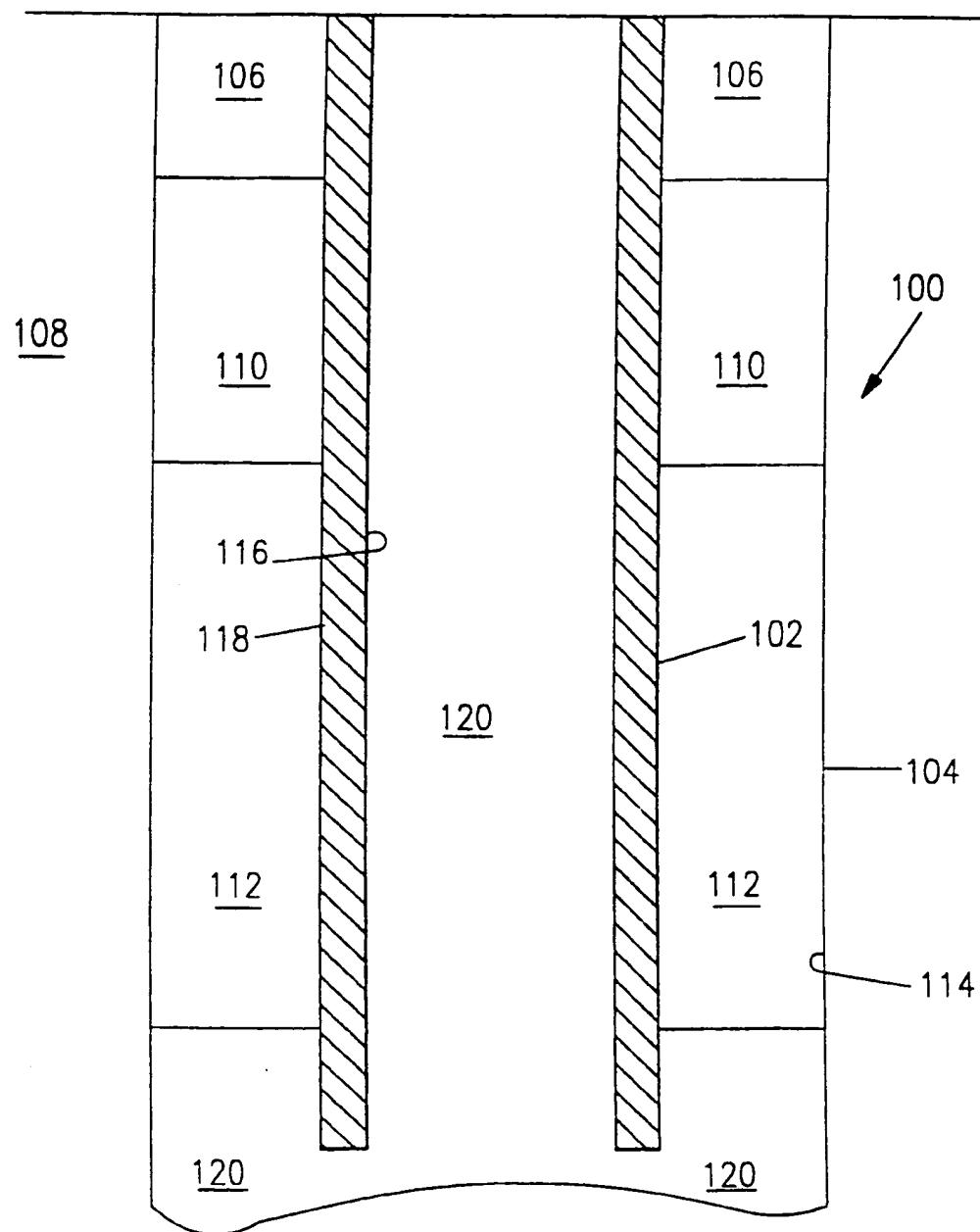


FIG. 2

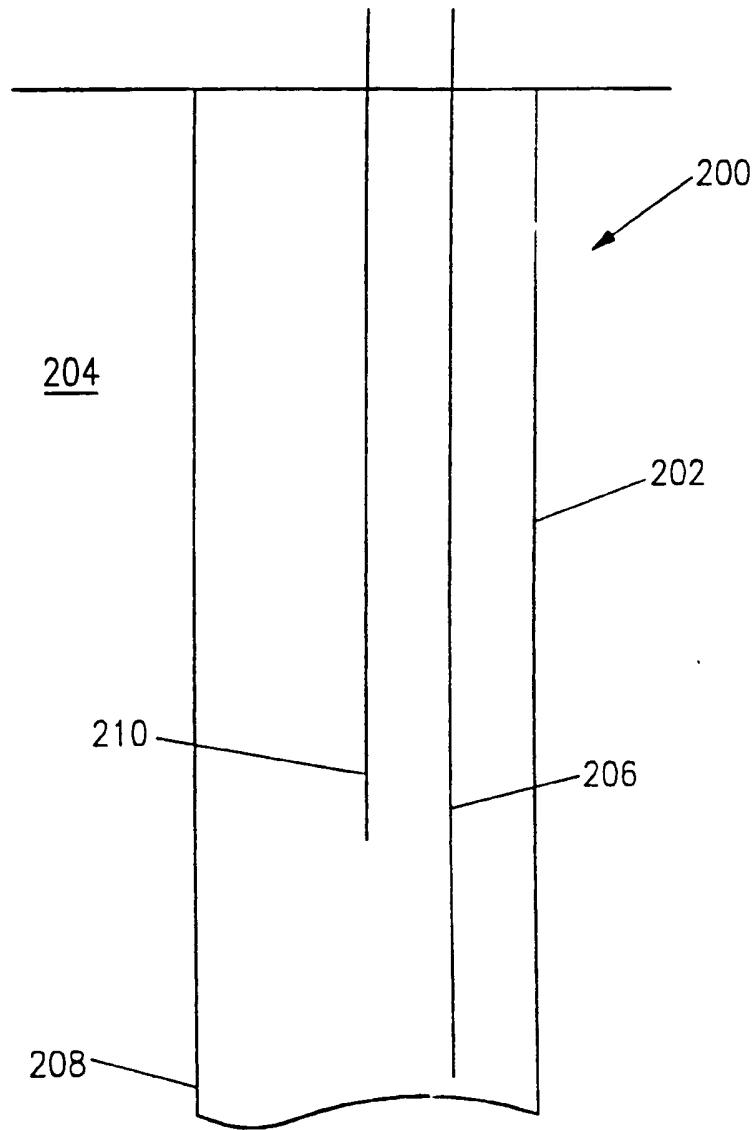


FIG. 3

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Inten	Application No
PCT/US 94/08729	

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**INTERNATIONAL SEARCH REPORT**Inten. Application No  
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## INTERNATIONAL SEARCH REPORT

Int'l. Application No  
PCT/US 94/08729

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 B01F17/00 B09C1/02 C11D3/43 E21B21/06 C09K7/06

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 E21B C09K C11D B01F B09C C23G B09B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search

Date of mailing of the international search report

11 January 1995

20.01.95

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Hilgenga, K

## INTERNATIONAL SEARCH REPORT

Intell... Application No  
PCT/US 94/08729

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